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Haemolytic Disease of Newborn Foals

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Introduction

HAEMOLYTIC disease in animals resulting from iso-immunisation of pregnancy by foetal red cell antigens appears to have been recognised first by Caroli & Bessis (1947). These workers described a disease syndrome occurring in mule foals and demonstrated antibodies in the mare dams capable of reacting with the erythrocytes of the donkey stallions concerned. Coombs, Crowhurst, Day, Heard, Hinde, Hoogstraten & Parry (1948) and Bruner, Hull, Edwards & Doll (1948) described a similar condition in thoroughbred foals in England and the United States respectively. Berthelon & Meynard (1949) reported the disease in thoroughbred foals in France.

The condition has since been described in pigs by Buxton & Brooksbank (1953) and has been produced experimentally in dogs by Young, Erwin, Christian & Davis (1949).

The present paper records the laboratory and clinical investigations made during four years, from 1949 to 1952 inclusive, in dealing with the condition in thoroughbred foals at Newmarket.

Materials and Methods

The material upon which the present observations were made comprised mares, foetuses and foals, principally from the Newmarket area, which were referred for investigation by practising veterinary surgeons.

Serological studies of the mares' sera and colostra were made by means of the direct agglutination test and the antiglobulin test of Coombs, Mourant & Race (1945), using anti-horse-globulin serum for the detection of "incomplete" agglutinins on available test erythrocytes sensitised by the sera or colostra under investigation. Erythrocytes for these tests were obtained from available horses in the absence of appropriate stallions' cells which were unobtainable. Titres of sera and colostra mentioned are those obtained with the most reactive cell tested in each instance, except where the use of foal's cells is specifically indicated. The direct antiglobulin test of Coombs, Mourant & Race (1946) was used to detect sensitisation of affected foals' erythrocytes. The techniques used were those described by Coombs *et al.* (1948).

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Samples of blood for haematological examination were obtained by jugular venipuncture and were collected in 10 ml. amounts in vials containing 0.03 g. of a mixture consisting of ammonium oxalate, 6 parts, and potassium oxalate, 4 parts. The examinations of these specimens were completed within two hours of obtaining them. Haemoglobin determinations were made by the oxy-haemoglobin method, using a photo-electric colorimeter, as described by Cronin (1952). The packed cell volumes were obtained by centrifuging portion of each sample in a Wintrobe tube at 3,000 r.p.m. for 15 minutes. Erythrocyte counts were impossible to make in several foals whose cells were clumped. In any event, it is considered that more accurate information is made available by careful packed cell volume and haemoglobin determinations. Blood films were stained by Leishman's method.

Post-mortem examinations were made within four hours of death in all cases. Portions of tissues for histological examination were prepared in a tissue processor employing formalin fixation and paraffin embedding. Sections were stained with haematoxylin and eosin.

Exchange transfusions were performed from 1949 to 1951 inclusive according to the technique described by Farrelly, Belonje & Cronin (1950). In 1952 the method described by Cronin (1953) was adopted.

Case Records

Mare 491

Prior to 1948 this mare had had uneventful pregnancies, but in that year she produced a foal which became affected with haemolytic disease and died in spite of simple transfusion therapy (Case 1, Coombs *et al.*, 1948). In 1949 the mare foaled normally and the foal was allowed to suck. Signs of haemolytic disease were observed when the foal was 24 hours old and a blood examination made at 30 hours of age revealed that the red cell count (R.B.C.) had fallen to 1,800,000 per cub. mm. and that the cells were sensitised. At this time the foal was very weak and was lying down unable to rise to suck unaided. The heart rate was 120 beats per minute and the respiratory rate was 60 per minute. The visible mucous membranes were icteric and haemoglobinuria was present. The mare's serum antibody titre was 8:1024 (titre of agglutinating antibodies 1/8 and of " incomplete " or non-agglutinating antibodies, 1/1024).

An exchange transfusion involving the infusion of 2,500 ml. of blood from donor " C " and the exsanguination of 2,000 ml. of foal's blood was performed. The donor was selected by simple cross-matching of donor and recipient bloods on a tile. Immediately after the operation the foal appeared stronger and sucked well. A blood examination next day showed the R.B.C. was 3,920,000 per cub. mm., but the serum was very icteric. During the next seven days the R.B.C. rose to 4,860,000 per cub. mm. and the serum became considerably less icteric. The foal was confined indoors for two weeks to prevent undue exertion and normal exercise was then allowed. Recovery appeared to be complete and no untoward sequelae have been reported as yet in this animal, which has been trained and has raced for a season, and has now been retired to stud.

In 1950 the mare foaled normally and the foal was not allowed to suck the mare until 36 hours old. During this time the mare was milked out frequently by hand and the foal was fed on a reconstituted dried milk product. The foal contracted a streptococcal infection and died from a septicaemia at 48 hours old. Erythrocytes from cord blood, blood from the foal at 30 hours and at 48 hours were shown not to be sensitised. *Post-mortem* examination revealed lesions typical of a septicaemia and on bacteriological examination a haemolytic streptococcus was isolated.

In 1951 the mare was mated with a different stallion and was subjected to serological tests at 13 and three days prior to foaling. These tests showed titres of 16:256 and 80:5120 respectively indicating active immunisation. Accordingly, at birth the foal was not permitted to suck until 36 hours old, when no antibodies for its red cells were demonstrable in the dam's milk. During this time the mare was milked out frequently and the foal was fed on colostrum from another mare. This colostrum had been stored at $-20°$ in a freezing chest until required. Penicillin and streptomycin were administered intramuscularly to prevent streptococcal and *Bacterium viscosum-equi* infection. The foal developed normally and at no time did its cells become sensitised.

In 1952 the mare was mated with yet another stallion. Her serum, when tested at 30 and 10 days before foaling, showed titres of 4:128 on both occasions, suggesting no new immunisation was occurring. At foaling the colostrum contained antibodies for certain horse red cells but not for the foal's cells, indicating that the pregnancy must have been a " compatible " one and that the antibodies in the colostrum resulted from sensitisation in a previous pregnancy.

Mare 492

This mare produced live foals in 1937, 1939, 1941, 1943 and 1947. She was barren in 1938, 1942, 1945, 1946 and 1948. Her foals died from undetermined causes in 1940 and 1944. In 1949 she foaled normally, but when three days old the foal was noted to be weak and to have pallid mucous membranes. The erythrocytes were sensitised and the R.B.C. was 3,800,000 per cub. mm. No treatment was attempted and the foal recovered spontaneously. It was not possible to obtain further blood samples from this foal. In 1950 the mare was not mated and she died in 1951.

Mare 493

This mare produced live foals in 1946, 1947 and 1948. In 1949 her foal died, having shown signs of haemolytic disease. *Post-mortem* examination revealed lesions typical of the condition and the erythrocytes were sensitised. The serum of the dam had a titre of 256:4096 at this time. The mare was barren in 1950, had a live, normal foal in 1951 with no special precautions taken at foaling time and in 1952 she aborted at 10 months. A coliform organism was isolated from the allantois-chorion and the erythrocytes of the foetus were not sensitised. At this time a titre of 4:16 only was demonstrable in the dam's serum.

Mare 494

This mare produced live foals in 1945, 1947 and 1948. She was barren in 1946. In 1949 her serum titre was 8:64 and her foal developed haemolytic disease. Its cells were sensitised and the visible mucous membranes became markedly icteric. The foal recovered without treatment.

In 1950 the foal's cord blood was negative to the antiglobulin test. The foal was allowed to suck 24 hours after birth and 20 hours later its cells were sensitised and the R.B.C. was 5,600,000 per cub. mm. The mare's serum titre was 64:1024. No further signs developed and the foal grew normally.

In 1951 tests showed the mare's serum titres 15 and 8 days before parturition to be 8:256 and 64:1280 respectively. The foal was not allowed to suck until three days old during which period the usual precautions were taken to milk the mare and feed the foal suitable colostrum. At foaling, the mare's colostrum had a titre of 256:40,000 when tested with the foal's cells. When permitted to suckle the foal, the mare's colostrum contained no demonstrable antibody. The foal's cells were not sensitised at birth and did not become sensitised after sucking. The foal developed normally.

In 1952 tests 30 and 7 days before foaling showed serum titres of 1:32 and 1:64 respectively. Suckling was prevented for 48 hours with the usual precautions and the foal lived normally. No samples of blood or colostrum were made available for testing.

Mare 495

This mare produced live foals in 1946, 1947 and 1948. In 1949 her foal died from haemolytic disease. No details of the course of the condition were given, but at *post-mortem* examination generalised icterus typical of the disease was observed and the erythrocytes were sensitised. The mare's serum had a titre of 2:1024. In 1950 this mare aborted twins and was barren in 1951 when she died.

Mare 501

This mare produced live foals in 1946 and 1949, was barren in 1947 and her foal in 1949 died from undetermined causes. In 1950, after a normal foaling, the foal, at 48 hours old, showed signs of icterus and had a heart rate of 200 beats per minute. The foal died at 50 hours old and a blood sample taken immediately prior to death had a R.B.C. of 1,759,000 per cub. mm. The erythrocytes were sensitised. The mare foaled normally in 1951 and the foal remained healthy. Tests of the mare's serum in 1952 at 19 and 12 days before foaling showed titres of 2:16 on both occasions. No precautions were taken at foaling and the foal's red cells did not become sensitised

Mare 502

This mare had one live foal in 1945. In 1946, 1947, 1948 and 1949 all foals died from what appeared on clinical grounds to have been haemolytic disease. In 1950 the foal was not permitted to suck, but was fed on a milk substitute. It died following infection with *B. viscosum-equi*. The mare was barren in 1951. In 1952 tests of the mare's serum made 65, 50 and four days before foaling all showed a titre of 64:128 suggesting no new immunisation in that pregnancy. At foaling the mare's colostrum was tested with the foal's cells and no reaction occurred. The foal was allowed to suck and its red cells did not become sensitised. A blood examination of this normal foal revealed a R.B.C. of 7,780,000 per cub. mm., a P.C.V. (packed cell volume) of 32 per cent. and an Hb. (haemoglobin content) of 11.0 g. per 100 ml.

Mare 503

This mare produced her first foal in 1950 and it became affected with haemolytic disease, showing signs when 48 hours old. The foal was weak and its mucous membranes were pallid. The erythrocytes were sensitised and the R.B.C. was 3,400,000 per cub. mm. Twenty-four hours later the count had dropped to 2,240,000 per cub. mm. No treatment was given and the foal died 12 hours later. The mare's serum titre was 256:1024. The mare was barren in 1951, but produced a normal foal with no precautions taken at foaling time in 1952.

Mare 504

This mare produced live foals in 1948 and 1949. In 1950 her foal was found to be acutely icteric when five days old. At this time the R.B.C. had fallen to 950,000 cub. mm. and although an exchange transfusion was attempted the foal died during the operation. The mare's serum titre was 64:256. In 1951 a test two months before parturition showed a serum titre of 4:64. No further samples were submitted for examination and the mare was allowed to suckle the foal normally. Pallor of the mucous membranes was noted by the owner 30 hours after birth and suckling was then prevented. When seen at 36 hours old the foal was quite strong, its R.B.C. was 4,710,000 per cub. mm., its P.C.V. was 21 per cent. and its Hb. content 7.8 g. per 100 ml. The erythrocytes were sensitised. Blood examinations were made every four hours the following day during which the R.B.C. fell to 3,970,000 per cub. mm., the P.C.V. to 19 per cent. and the Hb. to 7.0 g. per 100 ml. From this point the blood picture improved slowly until a week later the R.B.C. was 6,110,000 per cub. mm., the P.C.V. was 29 per cent. and the Hb. was 9.8 g. per 100 ml. The serum of the foal remained icteric for four days but then cleared rapidly. Penicillin and streptomycin were given to prevent infection supervening and the foal was permitted to suck the dam when 48 hours of age.

In 1952 pre-foaling tests of the mare's serum failed to reveal any antibody and at foaling the colostrum did not react with the foal's cells. However, after a normal birth, the foal developed epileptiform convulsions when 40 minutes old. It was anaesthetised with " Nembutal " intraperitoneally and two hours later was standing quietly. It was then found to be blind and to have no inclination to suck. It was fed by stomach tube and by bottle for 84 hours when it was induced to suck. The foal was then apparently normal, apart from its blindness.

Mare 505

This mare produced live foals in 1945, 1946 and 1949. Her foal died from unknown causes in 1947 and she was barren in 1948. In 1950 her foal, when

48 hours old, was seen to be icteric and weak. It had a heart rate of 160 beats per minute and a temperature of 102.5° F. Its erythrocytes were sensitised and the R.B.C. was 2,340,000 per cub. mm. The serum was distinctly icteric. The mare's serum titre was 64:512. Two and a half litres of blood from donor " C " were infused and 2,000 ml. of foal's blood removed. At the conclusion of the exchange transfusion the foal was stronger and its R.B.C. had risen to 3,230,000 per cub. mm. One week after the operation the count was 3,740,000 per cub. mm. and three weeks after the operation it had risen to 8,000,000 per cub. mm. The foal recovered completely as far as could be determined.

In 1951 the mare produced a normal foal with no special precautions taken at foaling time. No serum samples were made available for testing in that year. In 1952 the mare's serum, when tested 15 days before foaling, showed a titre of only 4:16, but at parturition this rose to 256:2048. Unfortunately, the foal was allowed to suck when about four hours old, after the mare allegedly had been hand milked. At seven hours of age the foal was pale and weak and had a R.B.C. of 4,690,000 per cub. mm., a P.C.V. of 24 per cent. and an Hb. of 8.5 g. per 100 ml. The erythrocytes were sensitised. At this time the colostrum had a titre of 20:160 against other horse erythrocytes. Twenty-four hours later the foal showed signs of pain, had a temperature of 97° F., a R.B.C. of 3,570,000 per cub. mm., a P.C.V. of 18 per cent. and an Hb. of 6.0 g. per 100 ml. The foal died six hours later, having received no treatment.

Mare 506

This mare produced live foals in 1946, 1947 and 1948. She was not mated in 1949. In 1950 her foal died and lesions typical of haemolytic disease were seen on *post-mortem* examination. The erythrocytes were sensitised. In 1951 her foal also contracted the disease. When seen at 40 hours of age it was very icteric and weak. Its R.B.C. was 1,150,000 per cub. mm., P.C.V. 7 per cent. and Hb. 3.6 g. per 100 ml. A few normoblasts were observed. The erythrocytes were sensitised. The foal died at 44 hours of age.

In 1952 tests of the mare's serum made 40 and 20 days before foaling showed titres of 2:32 on both occasions. No further serum sample was submitted before the mare foaled. The owner of the mare claimed that the usual precautions were taken at foaling and that the foal was not allowed to suck until 36 hours after birth, during which time the mare had been thoroughly milked by hand. In the event, the foal became jaundiced at five days old. Its temperature was normal, respiration rate was 66 per minute and the heart rate was 90 beats per minute. An haematological examination at this time revealed a P.C.V. of 21 per cent. and an Hb. of 7.4 g. per 100 ml. The erythrocytes were sensitised. The foal appeared bright and strong, but the mucous membranes were icteric. Streptomycin and penicillin were given. Frequent blood examinations were made during the following eight days and at the end of this time the R.B.C. was 6,800,000 per cub. mm., the P.C.V. was 29 per cent. and the Hb. was 10.0 g. per 100 ml. The foal recovered without further complications.

Mare 507

This mare had a live foal in 1949. In 1950 her foal developed haemolytic disease. Its erythrocytes were sensitised and the mare's serum had a titre of 0:64. The foal was weak and icteric and had a temperature of 103.5° F. It was given a transfusion of 2,500 ml. of blood from donor " C " and 2,000 ml. of its blood were removed. It died 30 hours after the operation and at *post-mortem* examination lesions of a septicaemia were found. A streptococcus was recovered on bacteriological examination. Prefoaling tests in 1951 and 1952 revealed no titre whatever in the mare's serum. No precautions were taken at foaling and in both years healthy foals were born. The cells of both foals were not sensitised following sucking.

Mare 508

This mare was barren in 1945, 1946 and 1951. She produced live foals in 1947 and 1949 and her foal in 1948 died from unknown causes. In 1950 her foal was seen to be jaundiced when two days old. It was weak and had a heart rate of 90 beats per minute and a respiration rate of 60 per minute. Its erythrocytes were sensitised and the R.B.C. had fallen to 2,700,000 per cub. mm. Following a transfusion of 2,000 ml. of blood from donor " C " and the exsanguination of 1,800 ml. of blood the foal underwent marked clinical improvement. Immediately after the operation a blood examination showed the R.B.C. to be 3,519,000 per cub. mm. This dropped to 1,950,000 per cub. mm. during the next five days, but then rose gradually again to 8,500,000 per cub. mm. during the following three weeks by which time the foal appeared perfectly normal. The mare's serum had a titre of 512:2048 at foaling time.

In 1951 the mare was barren and in 1952 serological tests made 30 and 10 days before foaling showed titres of 2:32 and 16:512 respectively. The usual precautions taken at parturition resulted in a live healthy foal being reared.

Mare 511

This mare was barren in 1946, 1948 and 1950. She produced a live foal in 1947 and her foal in 1949 died from undetermined causes. The foal of 1951 was presented for *post-mortem* examination and showed lesions typical of haemolytic disease and the erythrocytes were sensitised. The mare died in 1952.

Mare 512

This mare produced live foals in 1945, 1947 and 1949 and was barren in 1946, 1948 and 1950. In 1951 she produced a foal which became affected with haemolytic disease. Typical signs of the disease were seen at 48 hours of age and at this time the foal's red cells were clumped in their own serum, the P.C.V. was 24 per cent. and the Hb. was 7.6 g. per 100 ml. The erythrocytes gave a positive antiglobulin test. Twenty-four hours later the P.C.V. was 18 per cent. and the Hb. was 7.8 g. per 100 ml. During this time the foal appeared to be quite strong and was sucking well. The next day, at four days old, the P.C.V. had dropped to 3 per cent. and the Hb. to 5.0 g. per 100

ml., with considerable haemoglobinaemia. An exchange transfusion was carried out at this stage and 3,000 ml. of blood from donor " C " were transfused and 2,500 ml. were exsanguinated. On the day following the transfusion, the R.B.C. was 2,210,000 per cub. mm., the P.C.V. was 19 per cent. and the Hb. was 6.6 g. per 100 ml. Twenty-four hours later the foal died in convulsions. *Post-mortem* examination revealed extensive renal damage and the bladder contained a quantity of dark, coffee-coloured urine.

Tests in 1952 made six and three weeks prior to foaling failed to demonstrate any titre in the mare's serum. The cord blood of the foal, foal's blood prior to sucking and foal's blood some hours after sucking all were negative to Coomb's test. Several tests made with the mare's colostrum and the foal's cells gave similarly negative results. However, at 48 hours old icterus was observed in the foal's mucous membranes and at that time a blood examination showed the R.B.C. to be 7,400,000 cub. mm., the P.C.V. to be 40 per cent. and the Hb. 14.0 g. per 100 ml. Twelve hours later the blood values were: R.B.C. 5,820,000 per cub. mm.; P.C.V. 32 per cent., Hb. 11.5 g. per 100 ml. A further 12 hours later the R.B.C. was 5,450,000 cub. mm., the P.C.V. was 28 per cent. and the Hb. was 10.5 g. per 100 ml. During this time, apart from the icterus, the foal appeared perfectly normal. The icterus disappeared in about 10 days. No further blood samples were submitted for examination.

Mare 513

Live foals were produced by this mare from 1945 to 1949 inclusive. In 1950 her foal had to be destroyed on account of malformation present at birth. In 1951 her foal became affected with haemolytic disease. Signs of anaemia and increased heart and respiration rates were observed at 48 hours old and at this time the red cells were sensitised and the R.B.C. had fallen to 3,880,000 per cub. mm. The Hb. was 7.4 g. per 100 ml. Twelve hours later the R.B.C. was 3,420,000 per cub. mm. and the Hb. was 8.0 g. per 100 ml. No further blood samples were brought to the laboratory and the foal recovered without treatment. The serum titre of the mare was 8:64.

In 1952, pre-foaling tests 27 days and one day before foaling showed titres of 4:8 and 32:128 respectively, suggesting active immunisation of the mare during pregnancy. The usual precautions taken at foaling resulted in a live foal being reared. The foal was permitted to suck the mare 36 hours after birth, when no antibodies capable of giving a detectable reaction with the foal's erythrocytes were left in the mare's milk.

Mare 514

This mare produced live foals from 1940 to 1943 inclusive and also in 1947 and 1948. She was barren in 1944, 1946, 1949 and 1950. Her foal in 1945 died from undetermined causes. In 1951 she produced a foal which at 18 hours old was in a state of collapse, with blanched mucous membranes. Its erythrocytes were sensitised and the Hb. was 3.5 g. per 100 ml. An exchange transfusion involving the infusion of 3,500 ml. of blood from donor " C " and the exsanguination of 3,000 ml. of the foal's blood was carried out. At the conclusion of the operation the foal was considerably improved, being able to stand and suck quite well. At this time an haematological examination showed the R.B.C. to be 4,740,000 per cub. mm., the P.C.V. to be 23 per cent. and the Hb. 9.1 g. per 100 ml. During the next six days the foal appeared clinically well, but no blood samples were made available. On the sixth day a blood sample was brought to the laboratory and was found to have a R.B.C. of only 1,110,000 per cub. mm., a P.C.V. of 8 per cent. and an Hb. of 3.2 g. per ml. The foal died the following day. At autopsy icterus and pallor of all tissues were observed. The liver was bronze in colour, the kidneys dark blue-grey in appearance, and the bladder was filled with urine heavily laden with haemoglobin. The mare was barren in 1952.

Mare 515

Live foals were produced by this mare in 1945, 1948 and 1949. She was barren in 1946 and 1950. In 1947 her foal died from unknown causes. In 1951 her foal developed haemolytic disease but the characteristic signs were not observed until the foal was five days old. At this time the erythrocytes were sensitised and a blood examination revealed a R.B.C. of 1,860,000 per cub. mm., a P.C.V. of 10 per cent. and an Hb. of 3.6 g. per 100 ml. A few normoblasts were seen in blood films. The mare had a serum titre of 4:2048. The foal was extremely weak and icteric with a heart rate of 130 beats per minute. A transfusion of 3,500 ml. of blood from donor " C " was given and 3,000 ml. of blood were exsanguinated. The foal died four hours after the operation. At *post-mortem* examination generalised icterus of the tissues was found, together with emphysema of both lungs. The bladder was filled with coffee-coloured urine.

In 1952 tests of the mare's serum 24 and 10 days before foaling showed a titre of 1:512 on each occasion. The mare ruptured her uterus when foaling and died. The foal did not survive delivery by caesarean section. Its erythrocytes were not sensitised.

Mare 516

This mare produced live foals from 1945 to 1950 inclusive. In 1951 her foal, when four days old, was found to be weak and icteric. Its erythrocytes showed true " auto-agglutination " and also gave a positive reaction when tested with antiglobulin serum. The P.C.V. was 8 per cent. and the Hb. was 3.6 g. per 100 ml. Haemoglobinaemia was present and a few normoblasts were seen in blood films. The foal died when four and a half days old. In 1952 the mare aborted twins at eight months before any pre-foaling serological tests had been made. The erythrocytes of the foetuses were not sensitised.

Mare 517

This mare produced live foals in 1943, 1945, 1946, 1947, 1950 and 1951. She aborted in 1944 and was barren in 1948. In 1949 her foal died from a condition diagnosed as haemolytic disease on clinical grounds. In 1951 pre-foaling tests revealed no antibodies in the mare's serum and the foal was born and allowed to suck normally. It remained healthy

and its erythrocytes did not become sensitised. In 1952 tests made 60 and 30 days before foaling showed serum titres of 0:2 and 4:128 respectively. The foal's cells were not sensitised before sucking and the foal was not allowed to suck until 30 hours after birth when the colostrum was free of detectable antibody.

Mare 521

This mare produced live foals in 1948, 1949 and 1951. She was barren in 1950 and in 1952 her foal became affected with haemolytic disease. Signs of the condition were seen at about 12 hours old when anaemia and some acceleration of heart and respiration rates were noted. The urine was coffee-coloured. The foal's erythrocytes were sensitised and the foal's serum had a titre of 8:512. The mare's serum had the same titre. At 24 hours old the foal died before transfusion could be attempted. Lesions typical of haemolytic disease were found on *post-mortem* examination.

Mare 522

In 1948 this mare was barren. She produced a live foal in 1949, was not mated in 1951 and in 1950 her foal died from undetermined causes. In 1952 her foal became affected with haemolytic disease. When first seen at 18 hours of age it was very weak and had a heart rate of 120 beats per minute and a respiration rate of 100 per minute. The temperature was normal. The erythrocytes showed true "auto-agglutination" and also gave a positive reaction when tested with antiglobulin serum. The P.C.V. was 8 per cent. and the Hb. was 3.0 g. per 100 ml. Both mare and foal had serum titres of 8:1024. The foal was transfused with 3,500 ml. of blood from donor "C", and 3,000 ml. of blood were exsanguinated, but the foal died as the operation ended.

Mare 523

This mare produced live foals from 1940 to 1951 inclusive with the exception of 1947 when she was barren. In 1952 her foal was seen to be jaundiced at 36 hours of age. When examined at 48 hours the foal was very weak and unable to stand. It had a temperature of 101.5° F., a heart rate of 120 beats per minute and a respiratory rate of 70 per minute. The foal weighed only 58 lb. The erythrocytes were sensitised, the R.B.C. was 3,240,000 per cub. mm., the P.C.V. was 18 per cent. and the Hb. was 6.0 g. per 100 ml. The mare had a serum titre of 8:256. An exchange transfusion involving the infusion of 3,500 ml. of blood from donor "D", the removal of 3,000 ml. of the foal's blood and the final infusion of the sedimented cells of 500 ml. of donor blood was performed. Blood samples were not available for examination until 5 days after the operation, when the Hb. was 8.75 g. per 100 ml. The foal refused to suck after the operation, and had to be fed by stomach tube and with a bottle. Its heart rate fell to 80 beats per minute and the foal appeared somewhat improved clinically. However, nine days after the operation, when 11 days old, the foal died in convulsions. In the two days preceding death, it had been treated for acute constipation. At *post-mortem* examination there was found generalised icterus and haemoglobinuria. Some pyloric stenosis was present and the small colon and rectum were impacted with hard, dry faecal material.

Mare 524

This mare produced live foals in 1939, 1941, 1943, 1945, 1947 and 1949. She was barren in 1940, 1944 and 1950 and was not mated in 1942, 1946 and 1948. In 1951 she produced twins which were alive at birth and apparently normal. They died when 48 hours old having shown typical signs of haemolytic disease. The characteristic gross lesions of the condition were found at *post-mortem* examination, but the diagnosis was not confirmed serologically at that time. The mare was not in foal in 1952, but a serological examination in that year showed her to have a titre of 128:128 indicating previous iso-immunisation and supporting the tentative diagnosis of haemolytic disease as the cause of death in the 1951 foals.

Mare 525

In 1950 this mare produced a live foal. She was barren in 1951 and in 1952 her foal was observed to be affected with haemolytic disease at eight hours of age. At this time the foal was weak and markedly anaemic. Its respiration rate was 80 per minute, heart rate was 130 beats per minute and its erythrocytes were sensitised. The P.C.V. was 11 per cent. and the Hb. was 3.5 g. per 100 ml. The foal's serum had a free antibody titre of 128:1024. It was transfused with 5,000 ml. of blood from donor "A" and 4,500 ml. of blood were exsanguinated. Finally, the sedimented cells of 500 ml. of donor blood were transfused. Streptomycin and penicillin were administered. The foal was considerably improved after the operation and made an uneventful recovery. After transfusion the P.C.V. was 28 per cent. and the Hb. was 10.2 g. per 100 ml. One week later the P.C.V. was 22 per cent. and the Hb. was 8.2 g. per 100 ml. No further blood samples were submitted for examination and the foal was permitted free exercise after three weeks. The mare had a serum titre of 8:512 and her colostrum was not free from detectable antibody until 96 hours after foaling. The foal was permitted to suck at this time, having been withheld from the mare's milk since the discovery of the haemolytic disease signs.

Mare 526

This mare produced live foals from 1946 to 1951 inclusive. In 1952 her foal at 48 hours of age was noted to be weak and icteric. Its temperature was 104° F. The erythrocytes were sensitised and the R.B.C. was 2,850,000 per cub. mm., the P.C.V. was 9 per cent. and the Hb. was 6.4 g. per 100 ml. The mare had a serum titre of 64:512 and the foal's serum titre was 2:2. A transfusion of 3,500 ml. of blood from donor "A" was given and 2,500 ml. of foal's blood were removed. At the end of the exchange transfusion the sedimented cells of 500 ml. of donor blood were transfused. Streptomycin and penicillin were given. The foal was much improved following the operation and the R.B.C. had risen to 4,160,000 cub. mm., the P.C.V. was 26 per cent. and the Hb. was 8.9 g. per 100 ml. The blood values continued to improve slowly but quite steadily and

five days later were as follows: R.B.C. 5,320,000 per cub. mm., P.C.V. 26 per cent. and Hb. 10.4 g. per 100 ml. Clinically, the foal improved slowly also, although its respirations remained accelerated for about six days. The foal was apparently completely recovered 14 days after the operation.

Mare 527

This mare produced twins in 1950 which died. She had a live foal in 1951 and in 1952 signs of haemolytic disease were seen in the foal at 18 hours of age. The foal's cells showed true " auto-agglutination " and were also agglutinated by antiglobulin serum. The P.C.V. was 9 per cent. and the Hb. was 2.0 g. per 100 ml. Haemoglobinuria was present and the foal was very weak and unable to rise. The heart rate was 200 beats per minute and the respiration rate was 80 per minute. Both mare and foal had serum titres of 32:1024. The foal died at 22 hours old and at *post-mortem* examination typical lesions of acute haemolytic disease were found.

Discussion

A. Clinical Observations

(a) Principal Signs

The clinical manifestations of haemolytic disease in foals have been discussed fully by Parry, Day & Crowhurst (1949), Doll & Hull (1951) and by Doll (1952). It is not proposed, therefore, to discuss at length the clinical signs described in the case records already given. Examination of these records shows that the principal signs observed in foals suffering from an early and massive drop in erythrocyte numbers were those which would be expected to accompany an acute anaemia, *viz.*, tachycardia, accelerated respirations and severe weakness. The relative infrequency of the finding of haemoglobinuria is noteworthy and suggests that although the sensitised erythrocytes may be removed very rapidly from the general circulation, their breakdown is not always effected so quickly as to overburden the reticuloendothelial system or to exceed the renal threshold for haemoglobin. Icterus was found only in those foals which either lived for some time following the onset of illness, or which first showed signs of the disease some days after birth. In such cases the end-products of continued excessive haemoglobin breakdown (bile pigments) overload the capacity of the liver to excrete them.

(b) Haematological Findings

A review of the haematological findings in the cases described is of interest. In no case were reticulocytes seen in blood films although a few normoblasts were seen in films from cases 512 (1951 foal), 515 and 522. All these foals died. Hypochromasia and poikilocytosis were frequently noted, but no abnormality in number or type of leucocytes was seen. The absence of free haemoglobin from the sera of foals in which the red cell counts were very low, *e.g.*, cases 514, 522, 525 and 527, is notable. In only one foal, case 516, was haemoglobinaemia found, when the animal was four days old. It may be hypothesised that prior to haemolysis the sensitised erythrocytes are removed from the general circulation, apparently by the spleen principally. As described, in some instances this process evidently took place very rapidly, while in others it appeared to occur more gradually. This difference in speed of removal may be related to the serum and colostrum antibody titres of the dams or possibly more likely to the amount of antibody actually absorbed by the foals from the dams' colostra. In the absence of stallions' cells to make accurate determinations of serum and colostrum titres, it is not possible to discuss these potential relationships further, except to say that no evidence of a direct relationship between antibody concentrations and rapidity of red cell count drop in affected foals could be demonstrated.

It is difficult to explain why the removal of sensitised cells from the general circulation should be delayed in many foals. Possibly the rate of removal may depend on the extent to which cells are coated with antibody, cells being removed only when coated to a certain minimum extent. If this were the case, it would seem necessary to assume that the passage of antibody from mare to foal does not cease at 36 to 48 hours after birth as is generally suggested, but that such transfer may occur over a longer period. It is known that antibody may persist at low titre in milk for a considerable time (Bruner, Edwards & Doll, 1948), but it is considered that the mucosa of the alimentary tract becomes impassable to unaltered antibody about 36 hours after birth (Bruner, Doll, Hull & Kincaid, 1950). The history of the 1952 foal of mare 506 suggests that antibody may pass into the foal's circulation after 36 hours of age. In this instance the owner stated that sucking was not permitted until this time, yet the foal became icteric two days later. As this case was not supervised personally, it is not possible to be certain of what actually occurred. However, Howard & Cronin (1955) have reported one case of a foal in which apparent passage of antibody occurred 13 days after birth. In this case, the foal was not allowed to suck until 13 days old and prior to sucking its erythrocytes were not sensitised. Twelve hours after it had commenced to suck its red cells reacted " weakly " with antiglobulin serum. Such prolonged passage of antibody from mare to foal would assist in explaining the delay in fall of red cell count which occurs in some affected foals.

It is possible also that " weakly " sensitised cells are not removed from the circulation as rapidly as those more strongly sensitised, thus delaying the fall in red cell count. The hypothesis that sensitised cells are removed from the general circulation principally by the spleen prior to eventual destruction is supported by the nature of the clinical signs, the results of the haematological examinations and the *post-mortem* findings. Haemolysis evidently occurs later if the foal survives long enough, and depending on the rate at which erythrocytes are broken down, may be evidenced by haemoglobinaemia and/or haemoglobinuria, or by icterus only.

(c) Pathological Changes

As has been pointed out by Doll (1952) the nature and extent of the lesions depend, *inter alia*, upon the duration of illness in the foal. In foals which die within 24 hours of birth very little icterus, or pos-

sibly none, is seen, but pallor of the tissues is pronounced. In such cases the spleen is usually swollen and turgid. In a few instances terminal haemoglobinuria may be found, as in case 527. Histological examination of the spleen in foals which die within 24 hours reveals much engorgement of the pulp with erythrocytes, but this does not extend into the Malpighian corpuscles. The livers in such foals often show no pathological changes although some central necrosis and erythrophagocytosis by the Kupffer cells is occasionally observed. In a few foals in the present series irregularity of the liver cell columns with vacuolation of some cells was noted. Little change is seen in the kidneys of foals which die after a very short illness; sometimes congestion, particularly in the glomeruli, and very infrequently some cellular degeneration of the cells in the tubular portions of the nephrons is found. Evidently in these foals death is caused by acute anaemia before sufficient time elapses for any major pathological changes to take place.

In foals dying following an illness of a few days or longer, more pronounced gross lesions are found on autopsy, and histological examination reveals changes correspondingly more advanced. The liver shows marked degeneration with vacuolation and necrosis of the hepatic cells, principally around the central veins. In case 523 there were almost no normal liver cells present, most showing varying degrees of nuclear lysis and rhexis. The spleen in these older foals is usually congested, but not engorged with erythrocytes. Most of the splenic cells show some signs of degeneration and haemosiderin deposits are evident. Erythrophagocytosis is a frequent finding in these older foals also.

Very considerable changes are found in the kidneys of older foals. The glomeruli are often contracted in appearance, many of the cells having pyknotic nuclei. The extension of tubular epithelium into the glomeruli described by Coombs *et al.* (1948) was only infrequently found in the cases described. More frequently, extensive degeneration of the cells of the first and second convolutions and the ascending loop of Henle were observed. These cells showed pyknosis of their nuclei, fragmentation and lysis. The collecting tubules contained debris, apparently consisting of some cellular material with bile salts and haemoglobin derivatives. In some sections unaltered haemoglobin appeared to be present.

While jaundice in the earliest stages of the condition may be due wholly to the haemolytic process, it is evident that this cannot be so in the later stages. The pathological changes observed in the liver support this view, the hepatic damage apparently resulting both from the effects of prolonged anaemia and from the toxic effects of the jaundice itself. Both these factors must also be concerned in the causation of the lesions found elsewhere. Their effect, naturally, is not so great in the spleen where the toxic changes are infrequent and relatively slight. However, in the kidney, both factors produce considerable changes, particularly in the tubular portions of the nephrons. The lesser changes found in the glomeruli would suggest possibly that the tubular epithelium is more sensitive than the capsular cells to the toxic effects of decreased oxygen tension and heavy concentration of bile pigments.

(*d*) *Treatment*

The principles of treatment are the removal from the circulation of the foal of as much as possible of the sensitised erythrocytes which are destined for ultimate destruction, the removal of as much as possible of any free antibody in the foal's plasma, and the replacement of the elements removed with blood from a suitable donor. In less serious cases, ordinary good nursing and care with the prevention of undue exercise on the part of the foal and the administration of antibiotics during the first week of life are all that are required to ensure a successful outcome. In the severely affected foal exchange transfusion is the only method of treatment likely to meet with success. Early recognition of the disease is essential for a transfusion to be successful as the results of the present series of cases indicate. Table I shows that the transfusion of foals over 48 hours old, or having red cell counts below 2,500,000 per cub. mm., packed cell volumes below 10 per cent., or haemoglobin contents below 5.0 g. per 100 ml. is unlikely to be successful. The fact that transfusions performed on animals which had somewhat lower blood levels than those quoted were successful does not invalidate the general recommendation regarding these minimum levels, especially in foals over 24 hours old.

Apart from the condition of the patient, other factors affecting the outcome of a transfusion are (i) the volumes of blood exchanged, (ii) the nature of the donor blood, and (iii) the operative technique.

(i) The blood volume of thoroughbred foals does not appear to have been investigated, but the blood volume in adult horses has been estimated to be 9.7 per cent. of bodyweight by Reichert & Brown (1909) using the Welcker wash-out method, and 8.11 per cent. in a single instance by Cronin (1954) using the Evans Blue dye method. The plasma volume in adult horses has been determined by Courtice (1943) and by Cronin (1952) who obtained values of 5.1 per cent. and 5.2 per cent. of bodyweight respectively, using the dye method. Wasserman & Sharney (1950) discussed the theoretical considerations involved in determining the percentage of original whole blood and the percentage of original erythrocytes remaining in a patient at any stage of an exchange transfusion, taking into consideration the haematocrits of the donor and recipient at the beginning of the operation. The calculations of Wasserman and Sharney are in very close agreement with the actual results obtained in the transfusions described in this paper. This agreement would seem to confirm not only the accuracy of the theoretical calculations, but also the validity of assuming for foals a plasma volume/bodyweight ratio very similar to that found in adult horses.

The factors concerned in Wasserman and Sharney's calculations will not be discussed further here, except to say that to effect an exchange transfusion in a foal weighing 40 kg. and having a P.C.V. of 15 per cent., using donor blood having a P.C.V. of 40 per cent., approximately 7 litres of blood should be exchanged. At the conclusion of such a transfusion,

TABLE I

THE CLINICAL AND HAEMATOLOGICAL FINDINGS IN AFFECTED FOALS, THEIR FATES AND THE SERUM AGGLUTININ TITRES OF THEIR DAMS.

Foal	Age in hours when signs of haemolytic disease were first seen	Principal signs manifested	Blood values of foal when first seen				Fate of foal
			Red blood cell count millions per cu. mm.	Packed cell volume per cent.	Haemoglobin content g. per 100 ml.	Serum titre of dem (complete : incomplete)	
493	72	Icterus, weakness				256 : 4096	D
495						2 : 1024	D
501	48	Icterus, tachycardia	1·75				D
503	48	Anaemia, extreme weakness	3·4			256 : 1024	D
505 (1952 foal)	7	Anaemia, weakness	4·69			256 : 2048	D
506 (1951 foal)	40	Icterus and extreme weakness	1·15	7	3·16		D
516	96	Icterus, weakness		8	3·6		D
521	12	Anaemia				8 : 512	D
527	18	Tachycardia, weakness, haemoglobinuria		9	2·0	32 : 1024	D
504 (1950 foal)	120	Pronounced icterus and extreme weakness	0·95			64 : 256	TD
507[1]	36	Icterus, weakness, pyrexia				0·64	TD
512 (1951 foal)	48	Anaemia, icterus, weakness		24	7·6		TD
514	18	Acute anaemia, collapse			3·5		TD
515	120	Tachycardia, weakness	1·86	10	3·6	4 : 2048	TD
522	18	Accelerated heart and respiration rates, weakness		8	3·0	8 : 1024	TD
523	36	Icterus and weakness	3·24	18	6·0	8 : 256	TD
491	24	Icterus, tachycardia, extreme weakness	1·8			16 : 1024	TR
505 (1950 foal)	24	Icterus, weakness	2·34			64 : 512	TR
508	48	Icterus, weakness	2·7			512 : 2048	TR
525	8	Anaemia, tachycardia, weakness		11	3·5	8 : 512	TR
526	48	Icterus, tachycardia, weakness, pyrexia		9	6·4	64 : 512	TR
492	72	Anaemia, slight weakness	3·8				SR
494 (1949 foal)	48	Icterus				8 : 64	SR
494 (1950 foal)[2]	44	No signs	5·6			64 : 1024	SR
504 (1951)	36	Anaemia	4·71	21	7·8	4 : 64	SR
506 (1952 foal)	120	Icterus		21	7·4	2 : 32	SR
513	48	Anaemia, tachycardia	3·88		7·4	8 : 64	SR

D = died without treatment ; TD = died in spite of treatment ; TR = recovered following exchange transfusion ; SR = recovered spontaneously.

[1] = This foal had a complicating streptococcal septicaemia.

[2] = This foal was not allowed suck until 24 hr. after birth ; the mare had been hand milked in the meantime.

It was not possible to obtain complete data for all foals.

the foal would have only about 15 per cent. of its original whole blood and about 6 per cent. of its original erythrocytes. Its final haematocrit would be approximately 36 per cent. Such values would be entirely satisfactory. The volumes of blood exchanged in the transfusions described were insufficient to achieve such end results. In the majority of cases little more than 50 per cent. of the original whole blood was removed and the final haematocrits were appreciably lower than those of normal healthy foals. In practice, it is often not possible to exchange as much as 7 litres of blood, but when lesser volumes are exchanged it is useful to conclude the operation with a simple transfusion of about 500 ml. sedimented donor erythrocytes to assist in raising the final haematocrit of the foal to a safe level.

(ii) It is important that the donor blood should be compatible, *i.e.*, firstly, its erythrocytes should not possess antigens capable of reacting with the antibody in the foal's plasma derived from the dam's colostrum and, secondly, of somewhat lesser significance, its plasma should not contain any antibody capable of reacting with the foal's cells. In the present series of cases there were available only a limited number of horses to serve as donors and consequently in a number of instances incompatible transfusions were given. A further source of error lies in cross-matching the bloods of donor and recipient only. This procedure is unsatisfactory because the plasma of affected foals often contains only very low or undetectable amounts of antibody. It was found necessary to use the dam's blood for cross-matching purposes and also to use the antiglobulin technique in addition to direct agglutination as often the agglutinins in the dam's serum were almost wholly of the " incomplete " type.

(iii) The operative technique used from 1949 to 1951 inclusive, while it was generally satisfactory, had the disadvantage of requiring the patient to be maintained on the operating table for about four hours in one position. The technique used in 1952 required only about half this time to complete the

operation and permitted movement of the patient during the operation. These improvements appeared to contribute materially to the foal's prospects for recovery. Exchange transfusion should always be supplemented with supportive treatment, including the administration of antibiotics, confinement to prevent undue exercise, and attention to the relief of constipation which is frequently a complication of haemolytic disease.

(*e*) *Results of Exchange Transfusion*

Five foals recovered following exchange transfusion and seven foals died. In the first group subsequent serological examination of the dams' sera and the donors' cells showed that in four of the five cases, the transfusions were not completely compatible. In the 1949 foal of mare 491 the incompatibility was slight, as the dam's serum reacted with the donor's cells very much below its maximum titre. Nevertheless, as already noted, samples of this foal's blood examined after transfusion were markedly icteric for some time and the red cell count rose slowly, although quite steadily. In the case of 508, where later tests showed considerable incompatibility, the red cell count fell for some time after the transfusion, before commencing to rise again slowly. This seemed to indicate some destruction of the donor cells in this foal. In cases 525 and 526 complete compatibility was not achieved, but in each foal the available horse possessing the cells which reacted at the lowest titre with the dam's serum was used as a donor. The haematocrit of foal 525 dropped from 36 per cent. to 22 per cent. during the six days following transfusion, but the foal remained clinically well and made an uneventful recovery. No such fall in the haematocrit occurred in foal 526, but in this instance the degree of incompatibility as judged by the reaction between donor's cells and dam's serum was very much less. In one instance, the 1950 foal of mare 505, compatibility appeared to have been complete and a very steady and quite rapid rise in the foal's red cell count followed transfusion.

Of the seven foals which died following transfusion, four (1950 foals of mares 504, 512, 515 and 522) were too severely affected when treated for a successful result to be expected. The 1950 foal of mare 504 had a R.B.C. of less than 1,000,000 per cub. mm., 522 had an Hb. of less than 3.0 g. per 100 ml., and 512 and 515 not only had low red cell counts but were acutely icteric, being over four days old at the time of transfusion, when considerable hepatic and renal damage already had taken place. The *post-mortem* findings confirmed the presence of these changes.

In the case of 514 the failure of the operation can only be presumed to have been due to incompatibility of donor and foal bloods. Unfortunately, serological tests to confirm this were not possible as the mare was sent abroad. In the case of 523 subsequent tests with the donor's cells and dam's serum did show some incompatibility, but this foal, in addition to suffering from haemolytic disease was also affected by a nervous condition. This not uncommon disease of foals is of obscure aetiology and is evidenced by lack of sucking instinct and indefinite signs of cerebral derangement. Although acute nervous signs, including convulsions, were manifested immediately before death, *post-mortem* examination did reveal some icterus, haemoglobinuria and congestion of the liver, spleen, and kidneys in sharp contrast to the usual findings in foals which lived for as long while suffering from uncomplicated haemolytic disease. Had this foal not been affected with the nervous condition in addition to haemolytic disease it might have recovered in spite of the incompatible transfusion, as did other foals. The remaining foal, which died following transfusion, case 507, also was shown by subsequent tests to have received an incompatible transfusion. However, this foal was suffering from a complicating streptococcal septicaemia which very probably was the major cause of death.

It is clear that the giving of an incompatible transfusion is not always followed by a fatal result, but such a transfusion apparently lengthens the period of convalescence in those cases in which a fatality does not ensue. Incompatible transfusions have been concerned with other factors in the deaths of two foals and appear to have been the sole cause of death in one animal. Four foals were too severely affected for a successful result to be expected from transfusion. Incompatible transfusions were given to four of five foals which recovered following the operations.

At the present time, foals which recovered either spontaneously or following exchange transfusion appear perfectly normal and no untoward sequelae have been reported.

(*f*) *Prognosis*

A review of the cases described shows that 29 foals contracted haemolytic disease. Six of these recovered spontaneously, five recovered following exchange transfusion, seven died in spite of treatment and 11 died without treatment.

The prognosis in cases of haemolytic disease appears to depend upon a consideration of the following factors:—

(i) Age at which signs of disease are first seen.
(ii) The nature of the clinical signs.
(iii) The results of haematological examinations made when signs are first seen.
(iv) The titre of antibody in the dam's serum.

Table I shows for each affected foal as much of this information as was available and also the eventual fate of the foal.

(i) The times at which signs were first observed show an interesting variation between the groups of foals which recovered spontaneously, recovered following exchange transfusion and which died with or without treatment. In animals which recovered spontaneously signs were seen, on an average, 54 hours after birth, while in animals which recovered following transfusion, signs were first seen 30 hours after birth. In the cases of foals which died with and without treatment the average times of finding the first signs were 60 and 38 hours respectively. Naturally these times give no indication of the time when signs were first manifested so as to be detectable by a critical observer, since not all attendants in charge of the foals were equally experienced or

conscientious in frequently examining their charges. Undoubtedly in many of the severely jaundiced foals in which signs were first seen at three to five days after birth, some signs must have been manifested earlier but were disregarded by the attendant. In cases where the course of the condition was very rapid, *e.g.*, 521, 525 and 527, diagnosis probably was made as early as possible. No foal in which signs were seen in the first 24 hours of life recovered spontaneously. Foals successfully transfused were those in which signs were first observed within about 30 hours of birth and in which sufficient time had not elapsed for major pathological changes to take place.

(ii) The nature of the signs displayed did not vary significantly between the various groups, or from foal to foal, an important point in determining the value of clinical appearances in prognosis. It does not seem possible to determine from the clinical appear-

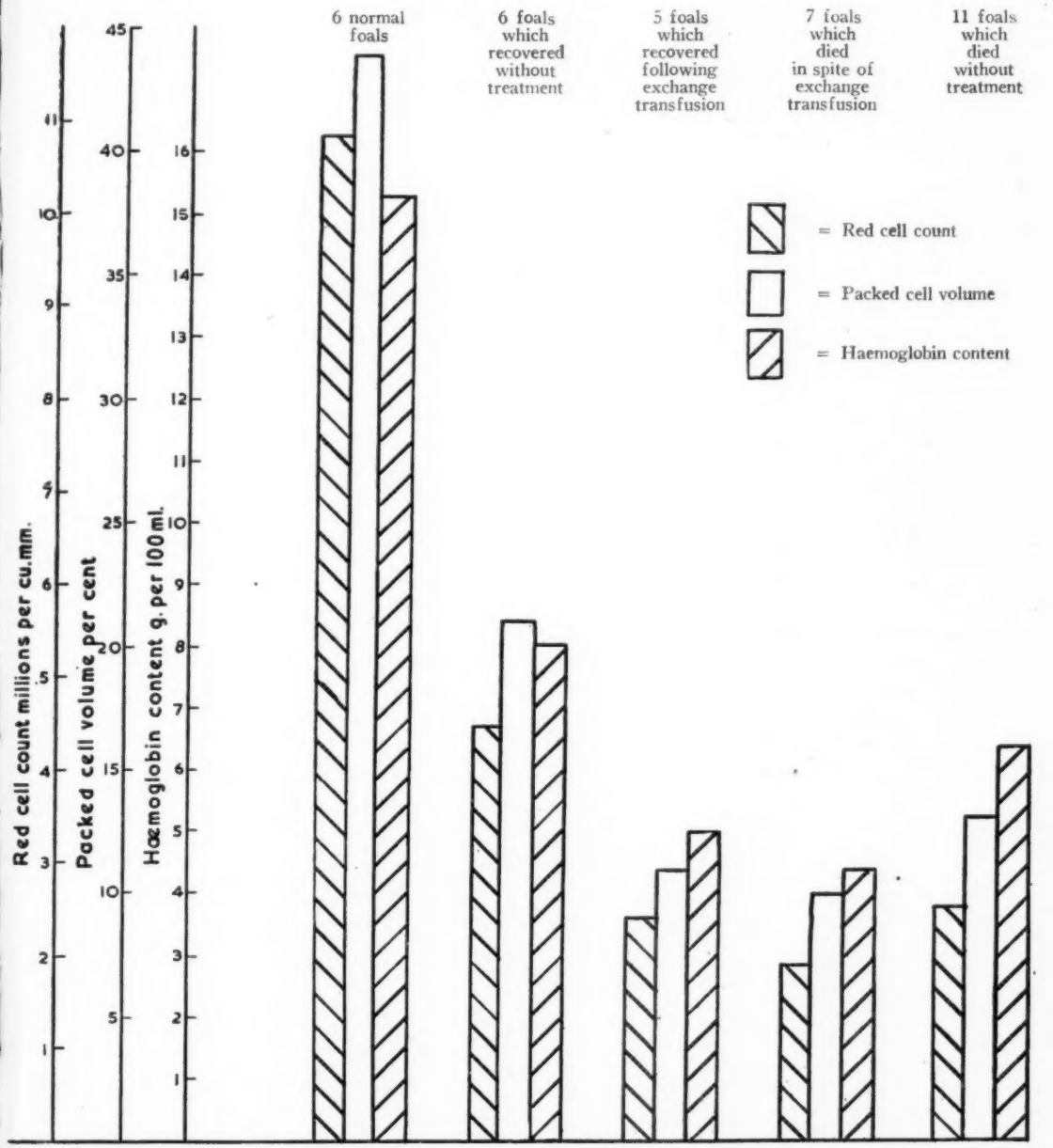
6 normal foals
6 foals which recovered without treatment
5 foals which recovered following exchange transfusion
7 foals which died in spite of exchange transfusion
11 foals which died without treatment
= Red cell count
= Packed cell volume
= Haemoglobin content
Red cell count millions per cu.mm.
Packed cell volume per cent
Haemoglobin content g. per 100 ml.

FIG. 1.—The average red cell counts, packed cell volumes and haemoglobin contents found in different groups of foals affected with haemolytic disease. The values for a control group of normal foals are also shown.

ances alone the likely outcome in any particular case of the disease. Jaundice and accelerated heart and respiratory rates were found in all groups. Extreme weakness, however, was not recorded in respect of any foal which recovered spontaneously.

(iii) The average blood values varied considerably between the various groups of foals and they are shown in Fig. 1. It is noteworthy that foals which recovered following exchange transfusion had blood levels at the time of diagnosis not very much higher than those found in foals which died with or without treatment, but it must be remembered that the foals successfully transfused were first examined much earlier in the course of the disease than were those which died.

(iv) Study of Table I indicates that in foals which recovered spontaneously, the dam's sera invariably had agglutinin titres not exceeding 8:64 and that the average titre for such mares was 6:56. (The titre of 64:1024 of mare 494 (1950 foal) is not included in the "spontaneous recovery" group for these purposes because this foal was withheld from the mare for the first 20 hours; if this had not been done, the foal undoubtedly would have been more severely affected and very probably would not have recovered without treatment.) In contrast, the titres of mares whose foals died or were saved by exchange transfusion all were considerably above 8:64, except in one instance, 507, in which the death of the foal was due in part at least to a streptococcal septicaemia. The average titres for these mares (excluding 507) exceeded 100:1000.

Consideration of these results would suggest that following diagnosis of haemolytic disease in a foal exchange transfusion should be considered as likely to be needed when one of the following circumstances exists:—

(i) Signs are shown within 24 hours of birth.

(ii) Weakness and inability to stand form part of the syndrome.

(iii) Blood values are less than 4,000,000 per cub. mm. R.B.C., or 20 per cent. P.C.V. or 8.0 g. per 100 ml. (Hb.) with the proviso in this instance that treatment may be withheld if blood examinations made at four-hour intervals do not show any further deterioration to levels appreciably below those quoted.

(iv) The dam has a serum titre of 1:64 or more for complete or incomplete agglutinins.

Insufficient data regarding the level of free antibody in affected foal's sera was obtained in the present investigation for any recommendation to be based on it. However, it appears that in foals having a serum titre of 1/512 for incomplete antibody the prognosis is poor.

The prognosis becomes progressively more unfavourable the longer signs have been in evidence, the more pronounced the icterus is, the lower blood levels are and the higher the dam's titre is. The criteria which suggest a foal is unlikely to respond to exchange transfusion are discussed on page 486.

(*g*) *Incidence*

Of the 27 mares encountered, five were first seen in 1949, eight in 1950, seven in 1951 and seven in 1952. It would seem as if the annual incidence of the condition were remaining fairly constant, representing about 1 per cent. of the mares foaling in the Newmarket area.

All mares, save one, 503, had had at least one pregnancy prior to producing a foal which developed the condition. Most mares had had several earlier pregnancies and a number of mares had had foals which had died from unknown causes, possibly including undiagnosed haemolytic disease, in previous years. The occurrence of the disease as a result of a first pregnancy is unusual as no such case has been reported from America and Brion (1949) has reported only one such case from France. It may be hypothesised that insufficient antibody production is stimulated during an "incompatible" first pregnancy to produce a dangerous concentration of antibody in the colostrum at foaling time. Of the 16 mares which had not had any foals which died prior to producing a foal which became affected with haemolytic disease, one had an affected foal in her first pregnancy, two in their second pregnancy, two in their third pregnancy, six in their fourth pregnancy, four in their seventh pregnancy and one in her thirteenth pregnancy.

Table II shows the results of breeding mares in seasons following the production of their first foal in which haemolytic disease was diagnosed positively by serological tests. Clearly, the recurrence of the disease as a result of subsequent pregnancies is dependent upon the mare's carrying a foetus having the same red cell antigen(s) to which the mare was previously sensitised, or upon her carrying a foetus with erythrocytic antigen(s) against which she is capable of producing antibody and to which she becomes sensitised.

TABLE II

THE RECURRENCE OF ISO-IMMUNISATION IN SENSITISED MARES

	Breeding Results in Each Year				
	1948	1949	1950	1951	1952
491	+ (1)	+ (2)	+ (1)	+ (3)	− (4)
493		+ (5)	B (6)	− (7)	A (8)
494		+ (9)	+(10)	+ (11)	+ (11)
501			+ (4 or 12)	− (4 or 12)	−(13)
502		+ (14)	+ (14)	B (14)	− (15)
503			+ (16)	B (17)	− (7)
504			+ (18)	+ (19)	− (20)
505			+ (21)	− (18)	+ (21)
506			+ (22)	+ (23)	+ (22)
507			+ (24)	− (16)	+ (25)
508			+ (22)	B (23)	+ (26)
512				+ (27)	− (28)
513				+ (29)	+ (29)
517		+ (30)	− (31)	− (16)	+ (32)

+ = iso-immunisation occurred; A = mare aborted; − = iso-immunisation did not occur; B = mare was barren.

The figures in parentheses refer to the identity of the stallions concerned.

The earliest year in which iso-immunisation is recorded for each mare is the first in which positive serological diagnosis was made.

No additional information on the mechanism of iso-immunisation is afforded by the present observations. Doll & Hull (1951) found considerable damage to the placentae in some mares whose foals developed haemolytic disease. However, numerous placentae with abnormal areas of scar or necrotic tissue or with areas denuded of villi have been found in cases where no evidence of haemolytic disease appeared in the foals, and it would be improbable that in all such cases the red cell antigens of the foal were compatible with those of the mare and incapable of sensitising her.

B. Serological Investigations

(a) Pre-mating Tests

In sensitised mares, pre-mating tests between the mare's serum and the prospective stallion's red cells have been recommended (Bruner, 1950). In the present incomplete state of knowledge of horse blood types and their mode of inheritance such tests would appear to be of little value. A mare may well be capable of producing antibodies to several different antigens and as her normal serum titre of antibodies for antigens to which she has not been sensitised may be very low, pre-mating tests might not detect them. Therefore, while a positive test would indicate that if the foal where to inherit the reacting red cell antigen(s) of the stallion, the mare's colostrum would contain antibody which would react with the foal's cells, either as a result of the earlier sensitisation or, if further immunisation took place, a negative result of such a test on the other hand would indicate only that the mare was not sensitised to any of the red cell antigens possessed by the prospective stallion, but it would not preclude the possibility of her becoming sensitised to them.. If a mating were made on the basis of a negative result in a pre-mating test, it would still be necessary to test the mare's serum near foaling time with the stallion's red cells, and then if such tests proved negative, the foal could be allowed to suck at birth. If a positive test were found at this time, the usual precautions to prevent sucking and to hand-milk the mare would have to be taken. It would seem simpler to mate sensitised mares in accordance with ordinary breeding requirements and then to make pre-foaling tests with the stallion's red cells, arranging procedure at foaling time according to the results of such tests.

(b) Pre-foaling tests

Erythrocytes of stallions to which mares were in foal were not made available for testing with sensitised mares' sera. Therefore, pre-foaling tests of such sera were made in duplicate using erythrocytes from two horses. The red cells of one or other or both of these animals were known to react with every iso-immune serum previously tested with them. Obviously such tests were not completely satisfactory in that possibly additional antibodies for antigens not possessed by the erythrocytes of either of the two animals being used may have been present in the sera under test. Also, it is conceivable that a serum might be found which would contain only antibody against an antigen or antigens not possessed by these erythrocytes. However, in the event, all mares whose sera reacted at significant titres had antibody concentrated in their colostra and no mare whose serum failed to react with these cells had any demonstrable antibody in her colostrum. This was probably quite fortuitous, but was very helpful in predicting from the results of pre-foaling tests whether or not a sensitised mare was likely to have antibody-laden colostrum at parturition.

As is shown in the case histories, mares known to have produced foals which developed haemolytic disease were tested in succeeding pregnancies, usually on two occasions, about 30 and seven days before foaling. Any rise in titre was taken to indicate that active immunisation by foetal red cell antigen(s) was in progress. In such cases a recommendation to adopt precautions at foaling was given at once. In other mares, in which the titre remained constant or in which no titre was demonstrable, it was recommended that the colostrum be tested at birth with the foal's red cells in order to ensure that the colostrum contained no antibody capable of reacting with the foal's cells. In the present series of mares, in no case where the serum antibody titre remained constant in the 30 days immediately preceding foaling did the colostrum antibody react with the foal's red cells. This also was probably fortuitous, since it seems quite possible for a mare to bear a foetus having red cell antigens identical with those which gave rise to a previous immunisation without necessarily undergoing immunisation in that pregnancy also. In such a mare, although no rise in serum antibody would be detected, the colostrum at foaling would contain antibody capable of reacting with the foal's cells.

The use of the appropriate stallion's red cells in pre-foaling tests would provide positive evidence as to whether or not immunisation was taking place. Even with the use of stallion's cells, however, the finding of a constant titre, *i.e.*, no fresh immunisation, would not necessarily indicate that the foal's cells would be susceptible to any colostral concentration of the same since the foal might not inherit the antigens possessed by the stallion's red cells if the stallion were heterozygous for these antigens. In this circumstance, therefore, in order to avoid the taking of unnecessary precautions at foaling, it would be better to test the mare's colostrum with the foal's cells at birth. Tests before foaling wih erythrocytes other than those of the stallion are not reliable, although they happen to have proved useful in the present series of cases. Where stallion's cells are not available and where pre-foaling tests with other red cells have failed to indicate the presence of antibody, it is quite essential to test the colostrum with the foal's cells at birth to ensure the safety of the foal.

In connection with the discussion of these tests it is of interest to refer to the 1952 foal of mare 512. No pre-foaling titres were found, no colostral antibody for the foal's cells could be demonstrated and no sensitisation of the foal's cells before or after sucking was demonstrable. However, a marked fall in red cell count with accompanying icterus was observed at 48 hours after birth. No other signs were seen and the foal soon became normal. This case is not included as a case of haemolytic disease in the

absence of a positive serological confirmation of the very suggestive clinical signs. However, the finding by Leroy & Spurrier (1953) of eight cases in women where the antiglobulin test as ordinarily applied failed to reveal antibody titres in the sera of the women, but where these sera very considerably enhanced the titres of other anti-Rh sera suggests that an analogous situation may possibly have been encountered in this mare. It is difficult to ascribe the clinical signs shown by the foal to so-called icterus neo-natorum or " physiological " jaundice.

(*c*) *Examination of mares' colostra and foals' erythrocytes*

Colostrum was tested with foal's cells in cases when the foal had not sucked and its cells were not sensitised. However, in many instances the foals' cells were useless for testing owing to sensitisation following sucking. In such cases colostral titres were obtained by testing with erythrocytes from the two animals whose red cells were used in testing sera and the observations made in connection with the accuracy of the serum tests also apply to tests with colostrum.

The antiglobulin test proved entirely satisfactory in detecting sensitisation of the red cells of affected foals. However, in one instance, the 1952 foal of mare 512, referred to above, in which the clinical signs strongly suggested haemolytic disease, no sensitisation was detected by the test. In one foal, 513, which recovered spontaneously and in whose dam the serum titre was only 8:64, the erythrocytes reacted slowly and " weakly " with the anti-horse globulin serum. It is not suggested that this " weak " antiglobulin reaction is necessarily related to the milder type of disease in this foal because, as has been pointed out by Roberts (1950), the relationship between the degree of sensitisation and the titre of the antiglobulin serum may not be direct.

(*d*) *Selection of blood donors*

Prior to 1952 only one horse (donor " C ") had been regularly available as a blood donor. In the early part of 1952, three additional animals (donors " A," " B " and " D ") were made available for this purpose, and the erythrocytes of all four donors were tested with a panel of 12 iso-immune sera then available. The results of these tests are included in Table III. These tests show that the four donor horses may be divided into two main groups of two each, *viz.*, group one embracing " A " and " B " and group two embracing " C " and " D." However, in neither group are the two donors identical

TABLE III

THE REACTIONS OF ANTI-ERYTHROCYTE ANTIBODIES PRESENT IN THE SERA OF 12 ISO-IMMUNISED MARES.

Red cells of	Serum of											
	491 (1949)	493 (1950)	494 (1951)	495 (1949)	502 (1950)	503 (1950)	504 (1950)	505 (1950)	507 (1950)	508 (1950)	513 (1951)	515 (1951)
491	0:0	1:4	2:8	0:0	32:64	1:4	0:4	1:1	0:8	64:128	0:0	1:512
491 (1952 foal)	0:0	1:512	1:16	0:0	128:128	2:16	4:4	0:0	0:32	0:1	0:0	1:512
493	0:0	0:0	0:0	0:0	32:512	0:0	0:0	0:0	0:512	512:512	0:0	8:512
493 (1952 foetus)	2:64	1:4	0:0	0:0	32:512	0:256	0:0	0:0	0:512	256:512	0:0	8:512
494	0:32	2:32	0:0	0:0	64:128	2:32	0:0	0:0	2:64	64:128	0:0	32:512
501	0:0	2:4	0:0	0:0	64:128	4:8	0:0	0:0	1:64	512:512	0:0	8:512
501 (1952 foal)	0:0	1:4	0:0	0:0	32:64	1:2	0:0	0:0	1:64	512:512	0:0	32:512
502	1:256	4:512	0:512	0:256	0:0	4:256	1:128	1:32	0:32	0:128	0:8	1:256
502 (1952 foal)	8:128	32:512	1:512	2:128	0:0	4:512	2:64	64:256	0:0	256:512	2:32	1:2
503	0:0	1:16	0:1	0:0	128:512	0:0	0:0	0:0	1:256	512:512	0:0	2:512
504	1:512	4:8	0:0	2:8	64:128	2:8	0:4	0:1	0:64	1:512	1:2	16:512
504 (1952 foal)	2:64	2:16	0:2	0:64	64:256	1:64	0:2	0:1	0:128	0:8	0:1	32:512
505	0:0	0:4	0:0	0:0	32:128	1:2	1:1	0:0	8:16	512:512	0:0	1:512
506	0:0	0:0	0:0	0:0	32:128	1:2	0:0	0:0	1:16	128:256	0:0	8:512
507	2:512	4:256	0:256	0:512	128:512	4:128	1:128	0:64	0:0	0:0	1:16	1:8
507 (1952 foal)	1:512	8:256	2:128	0:256	32:128	2:128	8:128	16:32	0:0	64:64	2:16	2:8
508	0:256	0:512	0:512	0:512	64:512	0:256	1:512	1:256	4:4	0:0	0:16	0:512
512	1:2	2:2	1:8	0:0	32-256	2:8	0:0	0:0	1:128	1:512	0:0	8:512
512 (1952 foal)	1:256	1:512	0:512	0:512	128:512	1:256	1:512	2:512	0:64	512:512	1:512	1:512
513	0:0	1:512	2:256	0:0	32:128	2:128	1:1	4:16	1:128	512:512	0:0	1:512
513 (1952 foal)	1:64	1:32	0:256	0:64	32:64	0:4	1:16	1:16	0:4	256:512	1:4	0:64
515	1:64	256:512	2:512	0:512	32:128	16:512	1:512	32:128	0:0	512:512	2:16	0:0
515 (1952 foal)	1:512	4:512	1:512	0:512	256:512	2:64	1:512	2:128	8:32	64:512	1:8	1:512
517	0:1	2:256	0:512	0:2	32:256	2:512	0:0	0:0	1:512	256:512	32:512	16:512
517 (1952 foal)	2:512	16:512	0:128	2:256	16:128	2:512	1:256	8:512	0:256	256:512	4:16	2:512
521	1:4	1:2	0:0	0:0	64:128	0:0	0:0	0:0	0:8	256:512	0:0	1:128
522	0:0	2:4	0:0	0:0	32:64	0:0	0:0	0:0	0:1	256:512	0:0	4:512
524	4:512	128:512	0:512	2:512	0:0	8:512	4:512	8:512	0:512	0:512	0:32	1:512
525	16:512	256:512	256:512	8:512	64:512	8:512	2:512	64:512	0:512	0:512	2:256	16:512
526	4:128	2:256	0:256	2:512	0:0	0:32	2:128	0:32	0:2	0:512	1:8	0:512
527	0:0	1:64	1:4	0:0	128:128	1:2	0:4	0:0	2:4	256:512	0:0	0:256
Donor " A "	2:1048	256:4096	2:512	2:1048	32:64	4:64	4:256	16:128	0:0	0:1	4:64	1:1
Donor " B "	2:128	64:2048	2:512	4:256	16:64	4:1048	4:128	8:512	0:2	256:512	4:16	2:2
Donor " C "	1:4	2:4	1:1	0:0	32:64	1:2	1:2	1:1	2:64	256:1024	1:1	4:512
Donor " D "	0:1	2:4	1:1	0:1	32:128	1:2	0:1	0:0	1:64	64:256	1:1	4:512

The figures show the titres obtained in each test (direct agglutination : indirect (antiglobulin) agglutination).
The dates in parentheses refer to the years in which the serum samples were obtained.

TABLE IV

THE REACTIONS OF ANTI-ERYTHROCYTE ANTIBODIES PRESENT IN THE SERA OF ISO-IMMUNISED MARES AND IN THE SERA OF FOALS AFFECTED WITH HAEMOLYTIC DISEASE, WHEN TESTED WITH THE ERYTHROCYTES OF NORMAL HORSES USED AS BLOOD DONORS

Red cells of	Serum of								
	AJ 2*	AJ 3*	AJ 7*	AJ 8*	AJ 9*	506 (1952 foal)	512 (1951 foal)	521	521 (foal)
Donor "A"	2:256	2:4096	0:1	1:32	4:256	1:4	1:8	4:512	16:512
Donor "B"	2:64	4:512	8:32	1:8	4:32	0:2	0:4	0:64	NT
Donor "C"	0:2	2:8	32:128	1:2	2:2	0:1	0:0	1:512	0:1
Donor "D"	0:0	2:2	16:64	0:1	1:2	0:0	0:0	1:512	NT

Red cells of	Serum of								
	522	522 (foal)	523	525	525 (foal)	526	526 (foal)	527	527 (foal)
Donor "A"	64:512	64:512	1:4	0:128	0:64	32:512	0:0	32:1024	32:1024
Donor "B"	0:1	0:1	NT	512:512	128:512	NT	0:1	NT	0:2
Donor "C"	1:1	1:1	8:256	128:512	8:512	64:512	1:4	8:1024	8:512
Donor "D"	0:0	0:0	NT	512:512	128:1024	NT	1:4	NT	0:1

The figures show the titres obtained in each test (direct agglutination : indirect (antiglobulin) agglutination).
* The sera from these iso-immunised mares were supplied by Dr. R. R. A. Coombs.
NT—Test was not made.

as Table III shows and as the results of further tests made with sera which became available later also show. The results of these additional tests are set out in Table IV. No iso-antibodies were found in the sera of any of the donors. The difficulty of obtaining from such a small panel of prospective donor horses a completely compatible donor for any foal is discussed on page 487.

(*e*) *Antibody specificity*

Coombs *et al.* (1948) showed that more than one antibody-antigen system was involved in the aetiology of haemolytic disease. A preliminary investigation conducted with 12 iso-immune sera, and erythrocytes from immunised mares, some normal foals and normal adult horses revealed results shown in Table III. It will be seen that these results merely confirm the findings of Coombs and his colleagues. Further work is in progress to determine the specificities of the antibodies involved.

Summary and Conclusions

1. The observations made from 1949 to 1952 inclusive on iso-immunisation of pregnancy in 27 mares and on haemolytic disease in 29 foals are recorded.

2. The clinical, haematological and pathological features of the disease in foals are discussed and the results of exchange transfusion therapy are described.

3. Criteria are suggested upon which prognosis and treatment in affected foals may be based. The treatment of severely affected foals consists principally of exchange transfusion and depends for its success on its performance early in the course of the disease. Mildly affected foals recover without treatment.

4. The annual incidence of iso-immunisation represents about 1 per cent. of the mares foaling in the Newmarket area. Some mares undergo iso-immunisation in successive pregnancies while others may have normal pregnancies subsequent to an affected one. Iso-immunisation occurring in a first pregnancy is recorded in respect of one mare.

5. Details of serological tests made on sensitised mares are given and they indicate that the prevention of haemolytic disease in the foals of such mares is now readily accomplished by pre-foaling serological tests of the mares' sera with stallions' erythrocytes and confirming the results obtained in certain cases by testing the colostra with the foals' erythrocytes. The results of these tests determine the necessity for precautions to be taken at foaling. Where indicated by such tests, these precautions, consisting of the prevention of the foal from sucking for about 36 hours, the substitute feeding of it during this time with other mare's colostrum, the administration to it of antibiotics and the frequent hand milking of the mare, have proved entirely successful.

6. Preliminary tests confirmed the earlier finding of Coombs *et al.* (1948) that more than one antigen-antibody system is concerned. Further investigation into equine blood types is required to identify the erythrocytic antigens involved and to determine their mode of inheritance. This knowledge is essential for the accurate and simple prediction of the possibility of the disease occurring as the result of any particular mating. In the absence of this information it is suggested that pre-mating tests of mares' sera and stallions' erythrocytes are of little value.

Acknowledgments.—The author would like to express his thanks to those veterinary surgeons who made available their cases for investigation. In particular, thanks are due to Messrs. R. C. Crowhurst, F. T. Day and G. H. Leader, all of whom participated actively in the investigation. Acknowledgment is also made of the considerable contributions to the work rendered by Dr. B. T. Farrelly in 1949 and 1950 and by Dr. C. W. A. Belonje in 1950.

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References

BERTHELON, M., & MEYNARD, D. A. (1949). *Rev. de Med. Vet.* (Toulouse), **100.** 113.

BRION, A. (1949). *Ibid.* **100.** 229.

BRUNER, D. W. (1950). *Cornell Vet.* **40.** 11.

———, DOLL, E. R., HULL, F. E., & KINCAID, A. S. (1950). *Amer. J. Vet. Res.* **11.** 22.

———, EDWARDS, P. R., & DOLL, E. R. (1948). *Cornell Vet.* **38.** 363.

———, HULL, F. E., EDWARDS, P. R., & DOLL, E. R. (1948). *J. Amer. Vet. Med. Assoc.* **112.** 440.

BUXTON, J. C., & BROOKSBANK, N. H. (1953). *Vet. Rec.* **65.** 287.

CAROLI, J., & BESSIS, M. (1947). *C. R. Acad. Sci.*, Paris, **224.** 969.

COOMBS, R. R. A., CROWHURST, R. C., DAY, F. T., HEARD, D. H., HINDE, I. T., HOOGSTRATEN, J., & PARRY, H. B. (1948). *J. Hyg.*, Camb. **46.** 403.

———, MOURANT, A. E., & RACE, R. R. (1945). *Brit. J. Exp. Path.* **26.** 255.

———, ———, & ———. (1946). *Lancet.* **1.** 264.

COURTICE, F. C. (1943). *J. Physiol.* **102.** 290.

CRONIN, M. T. I. (1952). *Vet. Rec.* **64.** 355.

———. (1953). *Ibid.* **65.** 120.

———. (1954). *Ibid.* **66.** 197.

DOLL, E. R. (1952). *Amer. J. Vet. Res.* **13.** 504.

———, & HULL, F. E. (1951). *Cornell Vet.* **41.** 14.

DUKES, H. H. (1942). "The Physiology of Domestic Animals." 5th ed. Ithaca, N. Y. : Comstock Publishing Co.

FARRELLY, B. T., BELONJE, C. W. A., & CRONIN, M. T. I. (1950). *Vet. Rec.* **62.** 403.

HOWARD, F. A., & CRONIN, M. T. I. (1955). *J. Amer. Vet. Med. Assoc.* **126.** 93.

LEROY, E. P., & SPURRIER, W. (1953). *J. Lab. & Clin. Med.* **42.** 85.

PARRY, H. B., DAY, F. T., & CROWHURST, R. C. (1949). *Vet. Rec.* **61.** 435.

REICHERT, E. T., & BROWN, A. P. (1909). "The Crystallography of the Hemoglobins." Carnegie Inst. Washington. (cited by Dukes, H. H., 1942).

ROBERTS, G. FULTON. (1950). *Proc. Int. Soc. Haematol.* **147.**

WASSERMAN, L. R., & SHARNEY, L. (1950). *Blood.* **5.** 925.

YOUNG, L. E., ERWIN, D. M., CHRISTIAN, R. M., & DAVIS, R. W. (1949). *Science.* **109.** 630.

F.A.O. APPOINTMENT FOR VETERINARIAN

Mr. W. Ross Cockrill, F.R.C.V.S., of the Animal Health Division, has accepted the offer of an appointment with the Food and Agriculture Organisation of the United Nations. He has, during the last two years, been acting as adviser to the Austrian Government on the control of animal diseases, and as veterinary consultant to the U.S. Mission for Economic Co-operation in Vienna. His new post is that of Technical Assistance Officer in the Agriculture Division of FAO, and he will be stationed at the Organisation's headquarters in Rome.

The appointment is not of a specifically veterinary character but is concerned with the planning and development of the Agriculture Division's programme of technical assistance to the underdeveloped countries.

Mr. Cockrill is the author of a book to be published in the autumn dealing with his experiences as a member of two Antarctic whaling expeditions.

Some Observations on Canine Semen

BY

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DURING the last 25 years many workers have carried out research and given us valuable information regarding the semen of most of the domesticated animals. The dog, however, has been rather neglected in this field, and very little data has been available.

This work was therefore undertaken in an attempt to gain information regarding canine semen, and thus bring it into line with similar studies of the other domesticated animals.

Alifanov (1934) made observations on 30 dogs which he divided into three groups: (a) those which attempted mating fairly promptly; (b) those which did so only after several hours' interval; (c) those which completely ignored the bitch. Collecting samples with an artificial vagina he found that animals of group (a) yielded 2.5 ml. of dense semen with an average count of 189 million sperms per ml.; in group (b) the volume was 2.0 ml. and a count of 74 million; and in group (c) 1.5 ml. and 14 million. He also demonstrated that sperm were produced continuously, and that the normal amount was restored after intervals of 24 to 72 hours.

Freiberg (1935), collecting by digital manipulation, states that the semen consists of three fractions: the excretion of the glands of Littré 1 to 2 ml.; the sperm-containing fraction 2 to 4 ml.; and the secretions of the prostate gland, up to 30 ml.

Lambert & McKenzie (1940) give the following data for the semen of the dog; volume of ejaculate 2 to 19 ml. and sperm concentrations of 10 to 90 million per ml.

Peters (1943) states that the mean volume in his recordings was 3.2 ml. and that he found no correlation between density and volume.

Hancock & Rowlands (1949) state that their records reveal a mean volume of 6.5 ml., and that the volume varied inversely with the density. Estimations of density gave a mean figure of 27 million sperms per ml.

Nooder (1950) in his investigations, using an artificial vagina, states that the volume of the ejaculate varies from 1 to 20 ml. He also says it is plainly visible that the ejaculation takes place in three phases. He describes the individual motility of good sperm as "intense", and states that the number of sperm per ml. varies from 88 to 588 million.

The general concensus of opinion amongst these workers would appear to be that a good sample of semen should not contain more than 20 per cent. abnormal spermatozoa.

Genitalia of the Dog

Of all the domesticated animals the reproductive system of the dog is probably the most simple anatomically. The testes, epididymes and ducti deferentes are essentially the same as those of the bull. Seminal vesicles and Cowpers glands however are absent, and

the only accessory sex organ present is the prostate gland (Figs. 1 & 2). Also, scattered in a somewhat indiscriminate manner throughout the mucosa of the cavernous urethra, are various mucous glands which probably correspond to the glands of Littré described in Man and other species.

FIG. 1.—Male genitalia of four-year-old Greyhound. Size compared to a 6-in. rule.

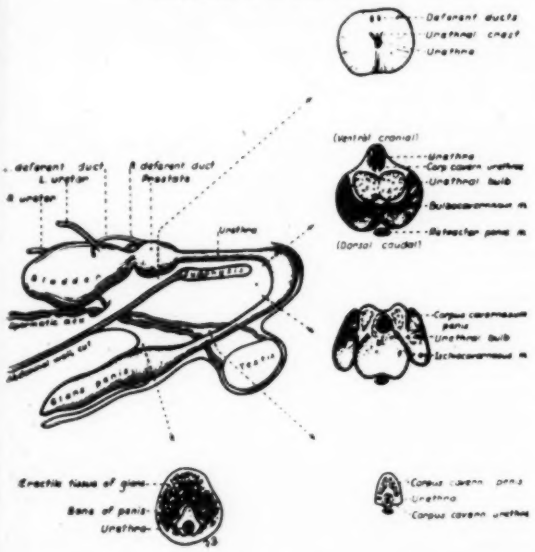


FIG. 2.—Diagrammatic sketch of Fig. 1. Also shown are cross-sections of the penis at various points. (Reproduced from "Guide to the Dissection of the Dog," by kind permission of Professor M. E. Miller).

The Semen

Volume

In the first instance samples were collected from various breeds by digital manipulation, but for various reasons this method was discontinued in favour of a specially designed artificial vagina (Harrop, 1954). It will be noted from the table below that considerable differences in volume were observed when the artificial vagina was employed as compared with digital manipulation.

From over one hundred collections from a variety of breeds the average volume was 9.5 ml., smaller breeds generally giving lesser amounts than the larger breeds.

Breed	Age	Volume	
		By hand	By A.V.
	Years	Ml.	Ml.
Greyhound ...	6½	2·5	9·0
„ ...	3	1·5	14·2
Dachshund ...	1½	1·2	7·5
Terrier ...	4½	1·7	8·0
Mongrel (large)	7	2·2	5·5
Greyhound ...	4	3·0	18·5

Average volume by hand collection 2·01 ml.
„ „ artificial vagina 10·41 „

Whole and Fractionated collections

After many whole collections had been made it was observed that the semen did tend to come in three fractions (Freiberg, 1935), and collections of these fractions were made. This was done by fitting a fresh tube on the artificial vagina after each fraction had been ejaculated (Figs. 3, 4 and 5).

The first fraction, which varies in volume from 0.25 to 2.0 ml., consists of a clear watery fluid, and contains few, if any, spermatozoa. It is probably the secretion of the urethral mucosa, the glands of Littré.

The second fraction is almost white in colour and much more viscous in consistency. It varies in volume from 0.5 to 3.5 ml., and is the true sperm-containing fraction.

The third fraction, which consists of prostatic secretion, is again clear in appearance and watery in consistency. The volume of this fraction varies from 3 to 20 ml., according to the breed and size of the dog, and it will also vary considerably in the same animal on different occasions. It contains few, if any, spermatozoa.

Evaluation of Semen

Immediately after collection the tube of semen should be placed in a water bath at about 35° C., in order that it may cool down gradually and not be subjected to thermal shock.

Visual examination

The colour of the whole ejaculate may vary from a watery grey to a milky white, the opacity varying directly with the density. On standing, the semen

FIG. 3.—Collecting an ejaculate in fractions, changing tubes between second and third fractions.

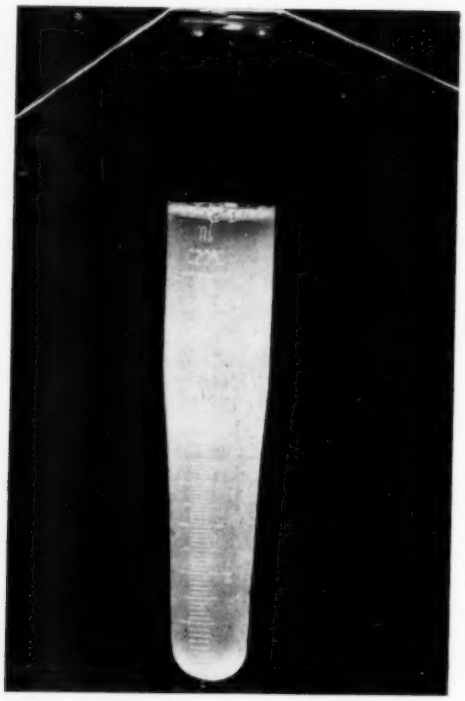


FIG. 4.—Complete ejaculate collected from a five-year-old Greyhound.

gradually separates into two layers, the sperm cells settling at the bottom.

Microscopical examination for motility

Immediately after collection an examination for motility should be made. A drop of semen is lightly spread on a warm slide with a glass rod. Normal semen will present a picture of tremendous activity, the whole mass appearing to have a rippling movement (unlike the "wave motion" of bull semen). Individual movements of spermatozoa are intense in fresh semen, and are best studied under a cover slip (Fig. 6).

RELATIVE SIZE OF INDIVIDUAL SPERMATOZOA OF THE DOG AND THE BULL

	Dog	Bull
Length	55–65μ	75–80μ
Breadth of head ...	3·5–4·5μ	5·5μ
Length „ „ ...	6·5μ	9·5μ

Density

Visual examination of density will give fairly reliable information regarding the quality of the semen, but an exact expression of density can only be made by defining the concentration of sperms per unit volume.

The technique of sperm counting adopted was similar to that commonly used for counting bovine spermatozoa, using a Neubauer haemocytometer. Dilution of the samples was 1 : 200 in formol-saline.

From over 100 collections, using an artificial vagina and utilising the whole of each ejaculate, an average figure of 125 million per ml. resulted. This figure is subject to considerable variation by individual breeds, by individual dogs of the same breed, and by each individual dog on different occasions, figures varying from 4 to 540 million per ml.

Supra-vital staining

Many methods of supra-vital staining were experimented with in order to try and obtain a foolproof method of examining semen, but, although some of these experiments were successful, it is not to be recommended as a reliable expression of the state of the semen. The procedure is too complicated for use in the field, and the results do not always express a true value of the semen.

Of all the methods tried, by far the most successful was the Eosin-Nigrosin Differential stain, using a technique of Erik Blom and now described.

On a warm slide a tiny drop of fresh semen is mixed with two drops of 5 per cent. Eosin in distilled water. After careful mixing for some seconds with a glass rod, four drops of 10 per cent. Nigrosin solution is added to the mixture, and the mixing process repeated. A thin smear of the final mixture is now made on a slide, and dried over a flame.

On examination the spermatozoa show up clearly on a brown velvet background, the live sperm remaining unstained, while the dead sperm take up the pink colour of the Eosin.

FIG. 5.—Ejaculate collected in the three fractions from the same dog as in Fig. 4.

FIG. 6.—Normal dog semen. Photomicrograph (× 635.)

Morphology

A simple and effective method of staining for morphological examination is to mix a drop of semen with a drop of Indian ink. The abnormalities seen in other mammals are also seen in the dog.

The Eosin-Nigrosin staining method may also be used for studying the morphology of sperms, using the same technique as with the Indian ink, viz: at least 100 sperms to be counted and examined individually under the $\frac{1}{6}$ objective. The number of sperms showing morphologically atypical features is recorded as the percentage abnormal spermatozoa.

pH

The *p*H of normal dog semen varies from 5.8 to 6.9 if taken immediately after collection. If kept it becomes more acid. The average figure obtained from dogs during these investigations was 6.75. There is no apparent breed variation.

If the three fractions of an ejaculate are tested separately, the average figures are—

first fraction	6.37
second fraction	6.10
third fraction	7.20

Effect of frequency of ejaculation on semen

In view of the rather conflicting opinions that have been expressed on this subject, experiments were conducted to ascertain if frequency of ejaculation had any detrimental effect on the quantity and quality of the semen. Collections were all made with an artificial vagina, and records kept of the volume, motility and density of each ejaculate.

The particular dog selected for this experiment was a four-and-a-half-year-old greyhound. This dog was in good condition, and had been recording an average count of 180 to 200 million sperm per ml., an average volume of 12 ml. and a motility rating of 4 in a range of 0 to 4. It was thought that by using a dog that normally gave a good performance the difference, if any, would be more marked.

Graph 1—volume in relation to frequency of ejaculation.

Graph 2—density in relation to frequency of ejaculation.

Graph 3—motility in relation to frequency of ejaculation.

Graph 4—a combination of all three factors.

One ejaculation per day was collected on 18 consecutive days. At no time did the dog appear to resent the collections, and he received no addition to his normal diet.

At the end of the experiment the dog was perfectly fit and showed no ill effects from the daily ejaculations. Five days after the experiment was over a further collection was taken from the dog, the results of which were—

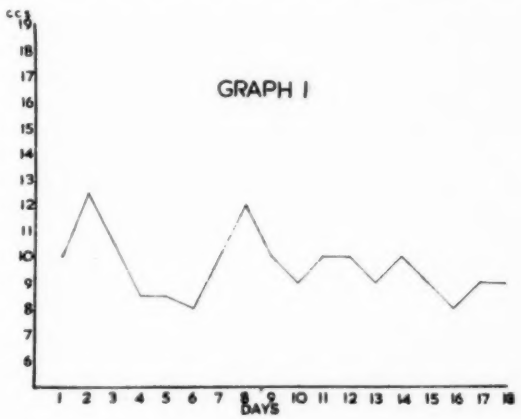
Volume	11.5 ml.
Motility	4
Density	115,000,000 sperms per ml.

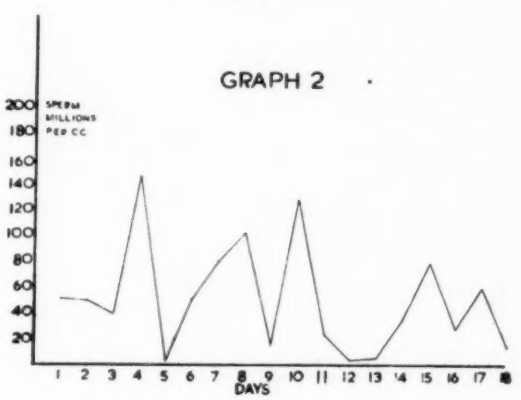
Rate of ejaculation

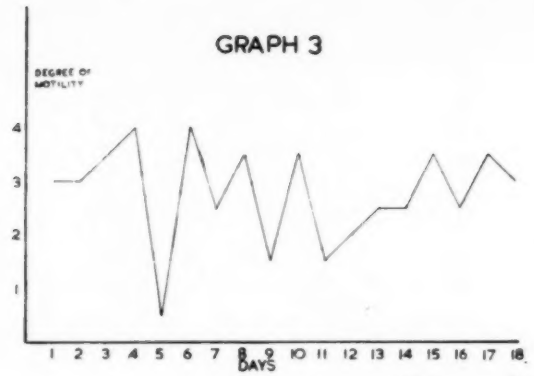
Several breeds were studied to measure the average time of ejaculation. The actual rate of ejaculation varies considerably both in breeds and in individuals, the chief variation occurring in the third fraction.

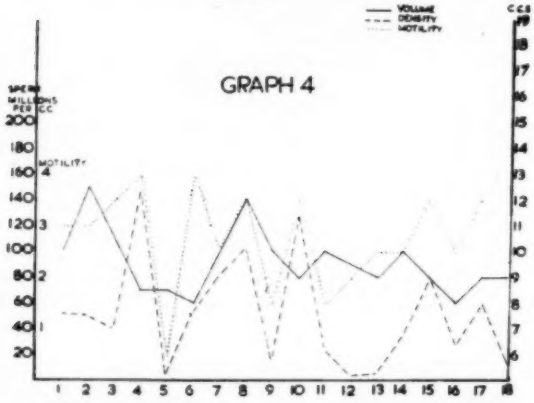
First fraction—this represents the time taken from when the penis is inserted into the A.V. until the first fraction ceases. Time—30 to 50 seconds.

Second fraction—this represents the time from when the first drop of the second fraction is seen









till it ceases. (In the normal dog the second fraction immediately follows the first fraction). Time —50 to 80 seconds.

Third fraction—this represents the time from when the first drop of the third fraction is visible until the ejaculation ceases. (Again this fraction immediately follows the second fraction). Time —3 to 30 minutes.

Discussion

The wide variation in the volumes of ejaculates recorded by earlier workers was doubtless due to the fact that most of them obtained their samples by digital manipulation. This method, while quite effective, does not always collect a true ejaculate, and it is obvious that the whole ejaculate must be collected before a true picture can be obtained.

When the ejaculate is collected in fractions a clearer picture manifests itself. Fraction one, apparently from the glands of the urethral mucosa, would appear to have no particular value other than perhaps that of a lubricant. Fraction two is the sperm containing fraction, while fraction three, the prostatic secretion, would appear to be the medium in which the spermatozoa travel up to the site of fertilisation.

The difference in the *p*H of these three fractions is interesting. The alkalinity of the third fraction appears to activate the more acid sperm-bearing second fraction. If a drop of the second fraction is placed on a warm slide and studied under the microscope one will observe a fair degree of motility, but this motility is very definitely increased if a drop of the third fraction is added to it.

In the normal dog, obviously, density will vary inversely with volume, according to the amount of prostatic fluid contained in the ejaculate. This will account for the great variation in figures given by earlier workers on the sperm counts, many of them obviously not having collected all the prostatic secretion and thereby getting a higher density.

The rate of ejaculation provokes some interesting speculation. According to figures obtained during these investigations a dog has ejaculated his first and second fractions in a matter of some 70 seconds, and one wonders how many keen but inexperienced sires have been condemned as sterile because they have voided fractions one and two in their first sexual excitement in trying to mount the bitch before they secure intromission.

It must be stated here that not every dog will react spontaneously to the collection, whatever method is adopted. Some dogs, especially those of a nervous disposition, require time to settle down and accustom themselves to their surroundings and to the operator before they will co-operate. It is, therefore, unwise to condemn a dog as being sexually inactive because it refuses to produce semen at the first time of asking. Also, even if the dog does co-operate immediately, it does not necessarily follow that his first ejaculation is a representative sample of his prowess.

The effects of frequency of ejaculation have already been well illustrated, and from this it would seem that, provided a dog is fit, it would be reasonable to suggest that he could be used at stud two or three times weekly, with appropriate rest periods being introduced according to the demands for his services. More frequent usage than this over a prolonged period will lead to a deterioration in the quality of his semen, abnormal types in the form of immature spermatozoa appearing.

Summary

A brief survey of the literature relating to canine semen is given.

The facts and findings of the investigations into the volume, density, motility, *p*H, frequency and rate of ejaculation are described, and later discussed.

Acknowledgments.—I wish to thank Professor N. J. Scorgie for his permission to carry out this work, and for his helpful advice and criticism. Also to acknowledge the assistance of Miss B. Calvert and J. M. Larkin, both technicians of the Animal Husbandry Department.

References

ALIFANOV, F. G. (1933–34). *Itogi rab. l-go vsesojuz. sovesc. iskisst. osem.* **118** (1935). Abstract in *A.B.A.* (1935). **3**. 585.

ANDERSON, J. (1945). The Semen of Animals and its Use in Artificial Insemination. *Tech. Comm., Imp. Bur. An. Breed. & Genetics.*

FREIBERG, E. A. (1935). *Sluzebn. Sobakovod.* No. 1. 4. Abstract in *A.B.A.* (1935). **3**. 41.

HANCOCK, J. L., & ROWLANDS, I. W. (1949). *Vet. Rec.* **61**. 771–779.

HARROP, A. E. (1954). *Brit. Vet. J.* **110**. 194.

LAMBERT, W. V., & MCKENZIE, F. F. (1940). Circ. U.S. Dep. Agric. No. 567.

NOODER, H. J. (1951). *Tijds. Diergsk.* **61**. 81–94.

PETERS, H. (1943). *Berl. Munch. tarztl. Wschr/Wien.* Abstract in *A.B.A.* (1945). **13**. 104.

Joint R.C.V.S.—B.V.A. Meeting

A meeting was held between the Preliminary Investigation and Advisory Committee of the Royal College of Veterinary Surgeons and representatives of the British Veterinary Association, on Wednesday, March 2nd, at the Royal College of Veterinary Surgeons.

The British Veterinary Association representatives referred to a letter written to the College asking for information on the procedure of the Preliminary Investigation and Advisory Committee, both as to complaints made to it and as regards the seeking of advice. Under the latter, the Association was particularly interested in the matter of assistants setting up in practice in the area of their former principals.

The Chairman stated that the Committee had two functions :—

(*a*) That of giving advice
  (i) to individual members of the profession ;
  (ii) to the general public ;

(*b*) That of investigating complaints against
  (i) veterinary surgeons and Supplementary Veterinary Register practitioners ;
  (ii) unqualified persons for breach of the Veterinary Surgeons Acts.

Advice

In the case of advice this could, in straightforward cases, be given by the President and the Chairman of the Committee, together with the Registrar, by drawing attention to the appropriate paragraph of the Guide to Professional Conduct or by acting on precedent and established custom.

Otherwise applications for advice were considered by the entire Committee. Where, in an emergency, advice had been given as above by the President and Chairman, this was reported to the Committee.

The procedure adopted generally is best shown by the specific matter raised by the B.V.A. representatives in the next paragraph.

Assistants Commencing Practice in Opposition to Former Principals

This problem usually arose under the above heading of advice ; either the assistant would ask if it was proper for him to commence practice in such circumstances, or, more rarely, the principal would ask the same question.

As soon as the College was satisfied that the enquirer had given all the relevant details, the substance of his enquiry was, with his consent, placed before the other party affected, who was asked for his comments or observations thereon. When these had been obtained to the satisfaction of the College, the entire matter was placed before the President and the Chairman in an emergency, or the full Committee in a less urgent case.

The Committee would then consider all the information supplied. It was open to the Committee, if it desired, to seek further information or to ask the parties to appear individually before it. There was no absolute right on the part of the parties to have any such interview, nor could the Committee subpoena members to attend and the Committee's decision as to this depended entirely on the facts in each case.

In other cases the Committee might ask a Council member to seek further information on the spot.

As soon as the Committee was satisfied in its own mind that it had all the information that it required, the advice was communicated to both the parties concerned.

The Effect of Advice

The Chairman emphasised for the College that the advice did not have the force of law. However, if any advice tendered to a member of the profession was disregarded, the member might lay himself open to a charge of conduct disgraceful in a professional respect being brought against him.

Complaints

The same procedure as has been outlined above was adopted in the case of complaints. The Committee had to be satisfied that there was in law a prima facie case against a person complained of, and that this could be substantiated in

(*a*) The Disciplinary Committee in the case of a complaint against a veterinary surgeon or a Supplementary Veterinary Register practitioner ;

(*b*) A Magistrate's Court in the case of an unqualified person.

In many cases, the Chairman stated, the College sought the advice of solicitors.

Prima facie Cases Based on a Complaint

As soon as the Committee had decided that there was a prima facie case which could be substantiated by evidence, the College solicitors were instructed to present the case before the Disciplinary Committee or a Magistrate's Court, according as to whether it affected a professional person or an unqualified person.

Evidence on Oath

The Chairman emphasised the difference in the powers of the Preliminary Investigation and Advisory Committee as compared with the Disciplinary Committee. The Preliminary Committee, even if it interviewed the parties concerned in an application for advice, or where a complaint had been lodged, could not take evidence on oath. It was only in the Disciplinary Committee, when a formal charge had been brought, that evidence could be given on oath.

Reopening of a Matter After Council's Advice had been Given or a Complaint Considered but not Placed Before the Disciplinary Committee

The Chairman, in answer to a question, stated that it was always possible to reopen any matter, provided that there was a good reason for doing so, such as the presentation of fresh evidence which had not been presented before the Committee when it made its

previous decision. Where, however, a person was dissatisfied by some previous decision of the Committee, it was not open for him to bring exactly the same matter on the same evidence before the Committee again.

Assistants' Bonds

In answer to a further question the Chairman stated that it was the firm opinion of the Council of the Royal College that all relationships between principals and assistants or partners should be regulated by a proper legal agreement. Generally speaking, where such an agreement existed, the Council would not intervene. Where such an agreement did not exist, the jurisdiction of the Council, even in the giving of advice, was strictly limited.

The ethical jurisdiction of the College depended on

(*a*) The maintenance of good relationships between practitioners and

(*b*) The maintenance of proper standards of professional conduct in the interests both of the profession and of the general public.

Any advice which the College might give must be such that if it was not complied with and a charge of conduct disgraceful in a professional respect was brought against the person concerned it could be upheld in the High Court should there be an appeal from the judgment of the Disciplinary Committee.

Conclusion

The B.V.A. representatives expressed themselves satisfied that the procedure outlined was as satisfactory as could reasonably be expected and wished to know whether the discussion at the meeting could be published since it would go a long way in allaying the fears of those members of the profession who felt that the procedure was inadequate.

News and Comment

R.C.V.S. DIPLOMA IN VETERINARY STATE MEDICINE

On the results of the examinations held at the Royal (Dick) School of Veterinary Studies in Edinburgh from June 9th to 14th, 1955, the following candidates were awarded the Diploma in Veterinary State Medicine:—

Garnett, Kenneth Jasper; Holmes, Robert Geoffrey; Morgan, Thomas Lewis Alwyn; Stewart, Thomas.

A SOCIAL OCCASION IN THE MIDLANDS

A party was held in Lichfield on Sunday, June 5th for the children of veterinary surgeons in the midland area. Mr. and Mrs. A. Steele-Bodger very kindly loaned their house and garden for the afternoon and the pleasantness of the surroundings coupled with the perfect weather made an important contribution towards the success of this venture.

The children ranged in age from four weeks (a thoroughbred veterinary surgeon already showing evidence of adaptability) to 13 years and all were most appreciative of the hospitality provided. Two or three of the fathers kindly took over the organisation of the various races and competitions, and a little light relief was afforded by the ladies' egg and spoon race and the men's sack race—the competitors in the latter event showing surprising agility. At 4.30 p.m. a sumptuous tea was provided for the exhausted competitors while the parents gossiped happily in another room over uncountable cups of tea and an excellent buffet meal. A treasure hunt followed in the garden and the party finally broke up at 6.30 p.m. with drinks for the adults and ice cream for the children.

Altogether well over £30 was raised for the Victoria Veterinary Benevolent Fund Ladies Guild, and the afternoon was voted a great success in every way. The committee responsible were Mrs. R. H. Owen, Mrs. J. M. Rorrison, Mrs. A. Steele-Bodger, and Mrs. H. W. Steele-Bodger, under the enthusiastic chairmanship of Mrs. Forbes Ritchie, and they most certainly deserve high praise and hearty congratulations.

PERSONAL

Births

BIGGS.—On May 27th, 1955, to Jan, wife of Peter Biggs, B.SC., M.R.C.V.S., 44, Royal York Crescent, Bristol, a daughter, Alison Sarah.

PARSONS.—On June 18th, 1955, to Pamela May Isted, wife of William Graham Parsons, M.R.C.V.S., of Milric House, Church Road, Kessingland, Suffolk, a daughter, Penelope Pamela.

WILSON.—On June 9th, 1955, to Chris, wife of John C. Wilson, M.R.C.V.S., of "Towy Villa" Springfield Road, Carmarthen, S. Wales, a daughter, Pauline Nicol.

WRIGHT.—On June 14th, 1955, to Joan, wife of James Wright, M.R.C.V.S., Hope Cove, Hythe, Kent, a daughter, Mary Jessica.

Golden Wedding

Mr. James H. White, the oldest practising veterinary surgeon in Liverpool, and Mrs. White, celebrated their golden wedding on June 14th. Mr. White qualified at Edinburgh in 1893.

R.C.V.S. OBITUARY

RHODES, Wilfred, of the Ministry of Agriculture, Hook Rise, Tolworth, Surbiton, Surrey. Graduated London, December 18th, 1925. Died June 20th, 1955, aged 52 years.

MR. A. H. MILNE

Mr. D. D. Ogilvie writes:—

"Sandy" Milne was an old friend of mine and the sad news of his death so early in his career will come as a great shock to all who knew him.

"Sandy" and I spent our boyhood together in Edinburgh and because he went to a rival school, Watsons, of which incidentally he was very proud, I had opportunities of playing games both with and against him. In opposition he was tough, resolute and courageous, in support wholehearted and unselfish.

These were qualities which "Sandy" took with him into the more important field of his professional life.

He had personal difficulties which, resolutely, he overcame and he was building up a career which I am sure would have been a credit both to himself and to the profession. The best was yet to come. The tragic accident which brought his life to a close has not only deprived us of a friend but the profession of one of its most promising members.

COMING EVENTS

June

29TH (WED.). Meeting of the Scottish Metropolitan Division, B.V.A., at the Moredun Institute, Gilmerton, 2.30 p.m.

July

1ST (FRI.). Ordinary General Meeting of the Society of Practising Veterinary Surgeons at the Dolwar Café, Carmarthen, 2.15 p.m.

Summer General Meeting of the North of Scotland Division, B.V.A., at the Veterinary Investigation Centre, Whitley Road, Longbenton, Newcastle upon Tyne, 12, 2.30 p.m.

6TH (WED.). Annual General Meeting of the A.V.T. and R.W.'s (Northern Region) at Harper Adams Agricultural College, Newport, Salop, 10.30 a.m.

14TH (THURS.). Summer Meeting of the Central Division, B.V.A., at The Royal Veterinary College, Streatley, Berks, 1 p.m.

20TH (WED.). Annual General Meeting of the Southern Region of the A.V.T. & R.W.'s at the Agricultural Research Council Field Station, Compton, Berks.

28TH (THURS.). President's Invitation Luncheon and General Meeting of the Midland Counties Division, B.V.A., at the Swan Hotel, Stafford, 12.30 p.m.

September

4th to 10th. 73rd Annual General Meeting and Congress of the British Veterinary Association at Belfast.

B.V.A. COUNCIL AND COMMITTEE MEETINGS IN LONDON

Wednesday, July 6th.—

10.30 a.m. Home Appointments Committee, at 7, Mansfield Street, W.1.

12 noon Parliamentary and Public Relations Committee, at 7, Mansfield Street, W.1.

2.00 p.m. Organising Committee, at 7, Mansfield Street, W.1.

Thursday, July 7th.—

10.30 a.m. Veterinary State Medicine Committee, at 7, Mansfield Street, W.1.

2.30 p.m. General Purposes and Finance Committee, at 7, Mansfield Street, W.1.

Friday, July 8th.—

10.30 a.m. Council Meeting at the Connaught Rooms, Great Queen Street, Kingsway, W.C.2.

ADDRESSES OF DISEASE INFECTED PREMISES

The list given below indicates, first, the county in which are situated the premises on which disease has been confirmed, followed by the postal address and date of outbreak.

Anthrax

Cumberland. Scales Farm, Embleton, Cockermouth; Parton Hall, Wiston (June 13).

Leics. Pasture Farm, Freeby, Molton Mowbray (June 13).

Wilts. Manor Farm, Charlton, Donhead St. Mary (June 14).

Yorks. Dobson's Farm, Burstwick, Hull; Midgeley Green, Baildon Green, Baildon, Shipley (June 14); Roach Grange Farm, Kippax, Leeds (June 16).

Swine Fever

Bucks. Cippenham Lodge, Cippenham, Slough (June 18)

Cornwall. Higher Southcott, Jacobstow, Bude (June 16).

Denbigh. St. Asaph Avenue, Kinmel Bay, Rhyl (June 14); Bettws Lodge, Abergele (June 16).

Dorset. The Laurels, Netherbury, Bridport (June 17).

Essex. 64, Wingle Tye Lane, Hornchurch (June 14); Mundon Hall, Mundon, Chelmsford (June 20).

Lanarks. 151, Glasgow Road, East Kilbride, Glasgow; Blacktongue Farm, Greengairs, Airdrie (June 17).

Lancs. Lane House Farm, Galgate, Lancaster (June 15); Bridge Hall Farm, Moss Side, Preston (June 16).

Lincs. Council Holdings, Walcot Dale, Tattershall Bridge, Lincoln (June 17); East Cottage, Legsby, Market Rasen (June 20).

Norfolk. R.A.F. Station, Bircham Newton, King's Lynn (June 13).

Staffs. Hagley Farm, Rugeley; 88, The Cape, Commonside, Brownhills, Walsall (June 17).

Stirling. Victoria Poultry Farm, Banknock, Bonnybridge (June 18).

Warwicks. Allotment Holding, Blackhorse Road, Exhall, Coventry (June 15); Piggeries, Marston Lane, Bedworth, Nuneaton; Abbey Farm, The Common, Earlswood, Birmingham (June 17).

Worcs. The Laurels, Redditch Road, Hopwood; Torton Farm, Harlebury, Kidderminster (June 14); Merebrook Farm Cottage, Hanley Swan, Worcester (June 17); 311, Baldwins Lane, Hall Green, Birmingham; Woodcote Green, Kidderminster Road, Bromsgrove; Caspidge House, Finstall, Bromsgrove (June 20).

Yorks. Bell Mills, Driffield (June 14); 34, St. Andrews Gardens, Doncaster (June 15); Morton Grange, Nunthorpe, Middlesbrough (June 16); Shooters Grove, Wood Lane, Malin Bridge, Sheffield; Park Hill Farm, Swallownest, Sheffield; Red House, Brampton En le Morthen, Whiston, Rotherham (June 18); 3, Enfield Lane Piggery, Sheffield (June 20).

CORRESPONDENCE

The views expressed in letters addressed to the Editor represent the personal opinions of the writer only and their publication does not imply endorsement by the B.V.A.

R.C.V.S. COUNCIL ELECTIONS

Sir,—I should like to thank all those members of the profession who voted for me in the election for the Council of the R.C.V.S. I shall do my best to be a worthy representative.

Yours faithfully,

H. G. LAMONT,

Ministry of Agriculture for Northern Ireland,
Veterinary Research Division,
The Farm,
Stormont,
Belfast.

June 10th, 1955.

"A WELL OF ENGLISH UNDEFILED"

Sir,—In THE VETERINARY RECORD of May 28th Mr. Paul Crosfield pleads for correct use of the English language. Surely it is always a dangerous thing to do this in writing since it gives critics the opportunity of studying the words and phrases chosen by the expert to see whether he is worthy of the exalted position to which he has raised himself.

As a minor critic may I make the following observations?

Firstly I should not have expected an expert such as Mr. Crosfield to fall into the common error of misusing the word "anticipate"; secondly I am surprised

that immediately before his paragraph entitled "catachresis" he should so mix his metaphors as to have nightmares during both afternoons and evenings; and thirdly I should have thought that the case for simplicity and exactness in the use of words would have been a little stronger under the heading of "clear writing" than under "lucid and accurate expository prose".

Yours faithfully,

D. D. OGILVIE,

Imperial Chemical (Pharmaceuticals) Limited,
Fulshaw Hall,
Wilmslow,
Manchester.

June 2nd, 1955.

THE USE OF TERRAMYCIN IN WHITE SCOUR IN CALVES

Sir,—I have received a circular from Messrs. Pfizers, Ltd., Folkestone, Kent, referring to the treatment of white scour in calves.

The cost of a 200 mg. dose is referred to and emphasis is laid on the nominal cost of giving one or three such doses of Terramycin Animal Formula Powder.

Reference is made in this literature to a contribution made by me in THE VETERINARY RECORD in September, 1954, and I wish to make it clear that the 200 mg. dose of Terramycin is not recommended as a result of that article. The doses used in Northern Ireland were in the form of two 500 mg. tablets given on successive days. Kafka in America has recorded the usefulness of a 200 mg. dose but this appears to be much too small a dose in this country. Already we have some reports from the field that it is necessary on occasions to give not less than 1 full gramme each day.

Yours faithfully,

J. K. L. PEARSON,

Veterinary Research Division,
The Farm,
Stormont,
Belfast.

June 17th, 1955.

VETERINARY EDUCATION

Sir,—It is only after two weeks' careful thought, and with due respect to the contributors, that I venture to comment on the Symposium on Veterinary Education concluded last week.

It is understandable that the study of science in the sixth forms of our public and grammar schools should be considered of dubious value, when so many eminent men, especially Lord Adrian, in his presidential address at the meeting of the British Association at Oxford last year, have expressed concern at the consequences of the misuse of atomic power, and penetrating knowledge of the workings of the human mind.

Nevertheless, can Great Britain afford to have young men spending three or four years between G.C.E. at ordinary level (*i.e.*, the qualification for matriculation), and the essentials of anatomy, physiology and biochemistry in their second year at college?

If the majority of veterinary students had private means, finance would cause no concern, but is the profession justified in asking for a breadth of education in non-utilitarian knowledge, when the cost has to be borne by the taxpayer (and ratepayer) in the form of overt grants to students, and in income tax concessions (especially in the case of deeds of covenant, which may bring a rebate of up to £150 per annum), to parents with the burden of offspring undergoing full-time education? Seventy per cent. of British students receive direct financial assistance, and many of the others come into the second category.

It is a platitude that we live on an island, and have to import 50 per cent. of our food in the face of increasing industrial competition from countries with lower standards (and food imports) than ours. We have also an ageing population, and the burden of National Service eating into our reserves of young men.

I wonder whether two years spent on a farm and getting to grips with some of the realities of the outside world, and the economic pressures moulding the industry which it will be their first duty to serve, would be of greater value to the potential veterinary surgeon than another two years as a schoolboy—that is, if G.C.E. in science at advanced or scholarship level provides him with no exemption from the first year of the course on reaching college.

If there be time to spare, would it not be better employed at a post-graduate level in mastering such disciplines as statistics?

Great Britain can survive only by developing science and by increasing the artefact as much in agriculture as in any other industry.

Liberal education has an important place in a man's hours of leisure, but in an atomic age competence in one's mode of earning a living will be of supreme personal importance.

Yours faithfully,

B. L. EDWARDS,

York House, Station Road,
Whitchurch, Shropshire.

June 17th, 1955.

Sir,—Veterinary education is the concern of the whole profession, and I note with pleasure the publishing of contributions to the recent symposium.

I am disturbed to see some authors advocate the compulsory study of physics, chemistry and biology during the first year. Post-war scholarship and National Service requirements mean virtually all students have already studied the preliminary sciences up to an equivalent standard at school. Mere repetition! What a waste of time, talent and public money.

I cannot reconcile this practice with the so true theme of the symposium; too many facts to absorb in too short a time leads to "no freedom for cultural development." Here is a whole year!

Yours faithfully,

L. A. HEMSLEY,

c/o 312, Lower Addiscombe Road,
Croydon, Surrey.

June 19th, 1955.